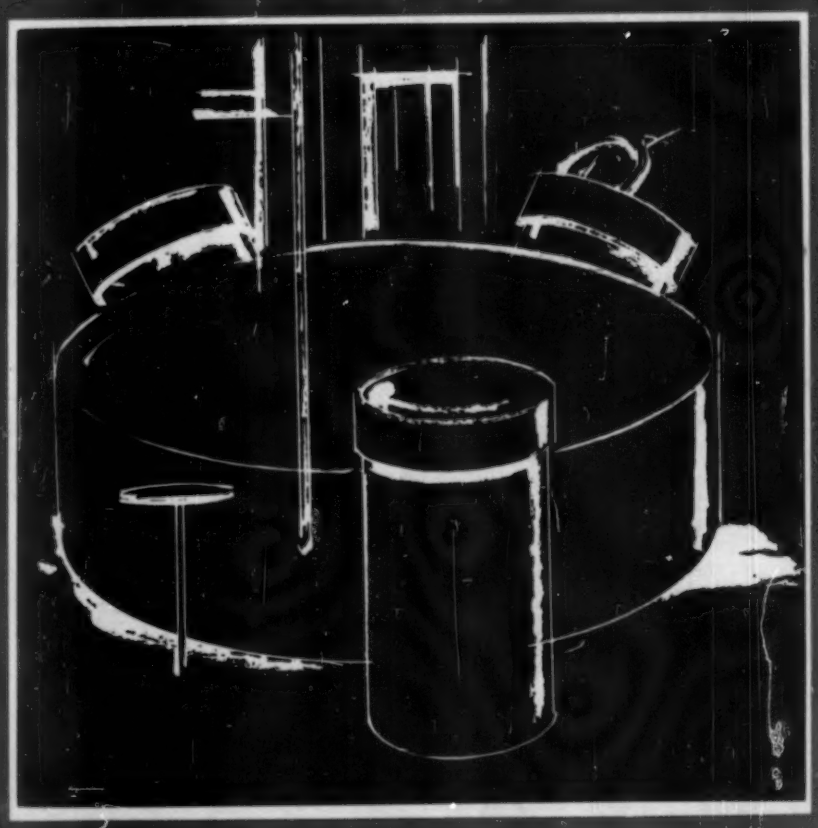
THE SOCIETY OF

PLASTICS ENGINEERS JOURNAL



HIGHLIGHTS ON
BULK AND SOLUTION
POLYMERIZED
PVC COPOLYMERS
(See page 21)

STEVENS RICE
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ANN ARBOR, MICH.

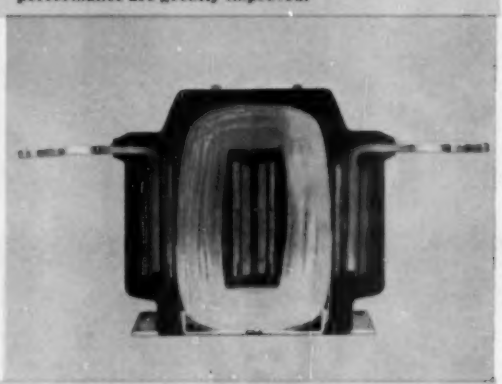
DECEMBER, 1958 • VOLUME 14, NUMBER 12

At Canadian General Electric Company, Limited:

Previous, asphalt-impregnated transformers, made by Canadian General Electric, Limited. Insulation strength was limited.

Streamlined transformers, molded with Epon resins, have superior insulation, dielectric strength; accuracy, performance are greatly improved.

Following curing period, the mold is quickly unbolted and the Epon resin-potted transformer removed.



Cutaway view of new instrument transformer clearly shows the complete penetration of Epon resins.

Epon® Resins improve performance, streamline appearance of instrument transformers

When Canadian General Electric Company, Limited, Toronto, Canada, decided to produce a new line of instrument transformers, they were faced with several critical problems: how to ensure performance, reliability, and appearance . . . all on a mass-production basis.

They solved all their problems with Epon resins.

Result: these handsome new transformers, completely impregnated with Epon resins, have high insulation and dielectric strength, good impact resistance, excellent heat dissipation, and increased ability to withstand creepage. Cracking and oxidation are virtually eliminated.

If potting, laminating, sealing or encapsulation play an important role in your operations, be sure to investigate Epon resins. They may be able to solve a production problem for you. For assistance and technical information, write to your nearest Shell Chemical office listed below.

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Optics Mfg. offers lifetime guarantee for projector case made of MARLEX*

"We picked MARLEX for our new slide projector case and height adjustment knob because it is the least expensive type of plastic material that has the required rigidity, resistance to heat and impact, colorability and gloss," says Herbert R. Leopold, Vice President of Optics Manufacturing Corp., Philadelphia, Pa.

"Our new Opta-Vue is the first projector on the market with a thermoplastic housing. Since this was a design innovation, we had to be sure to select a suitable resin, so we tested them all. One "high-impact" plastic lasted just 4 hours in our heat test before it melted! Another "heat-resistant" plastic cracked in several places in our drop test. MARLEX was the only material tested that matched all our specifications and passed all our tests. In fact, we advertise a lifetime guarantee for all MARLEX projector components!"

Whether your major interest is injection moldings, vacuum moldings, extrusions, filaments, sheet or transparent film, you will find that MARLEX is the best thermoplastic resin for the job. In fact, no other material serves so well, and so economically in so many different applications.

How can MARLEX serve you?

*MARLEX is a trademark for Phillips family of olefin polymers.

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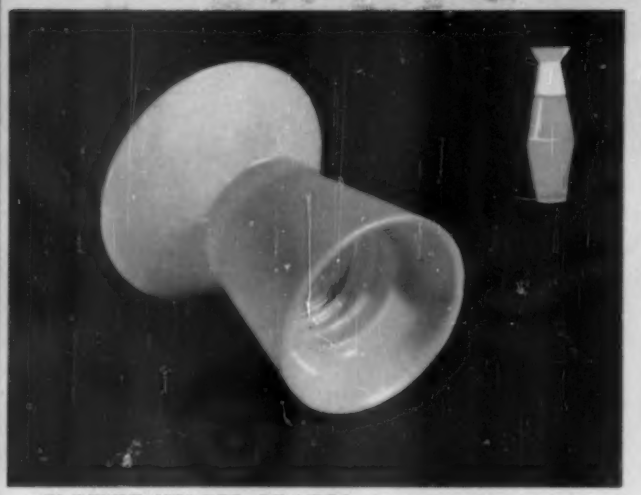
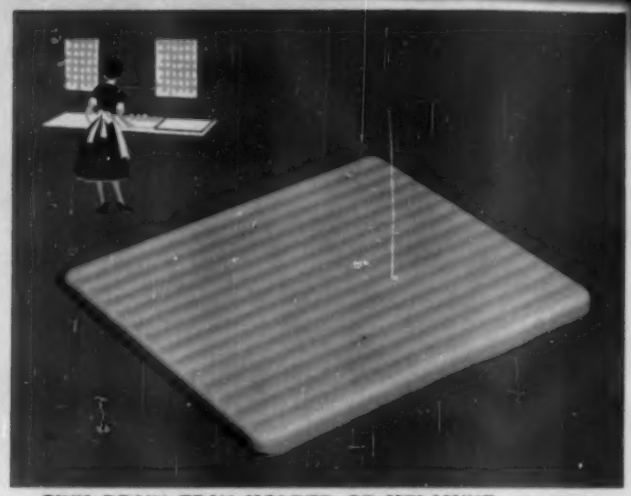
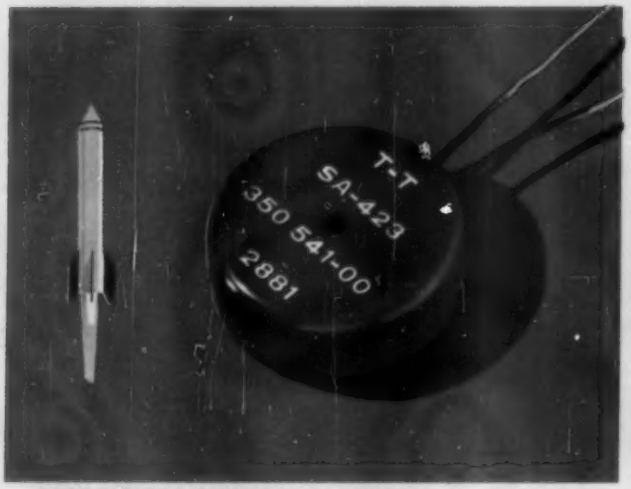


CLOSURE MOLDED OF UREA. This is a double reverse taper closure for Max Factor's Hypnotique Parfum-Cologne. Urea molds readily, and various types are available to meet individual job requirements and plasticities.

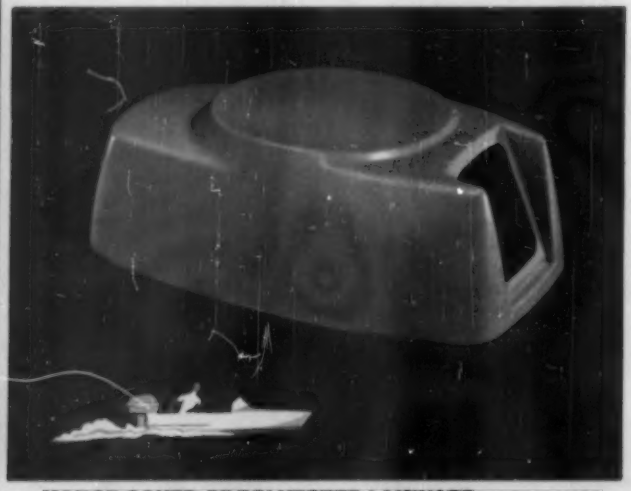


SINK DRAIN TRAY MOLDED OF MELAMINE. Kohler's movable melamine sink drain tray is strong, rigid and rust-proof. Available in over 12,000 colors, melamine can be compression- or transfer-molded.

HEEL LIFTS MOLDED OF NYLON. Nylon's outstanding resistance to abrasion gives these heels several times the life of ordinary lifts. PLASKON Nylon, with high molten viscosity for ease of handling, is available in several types to meet the requirements of extrusion, injection and blow molding.

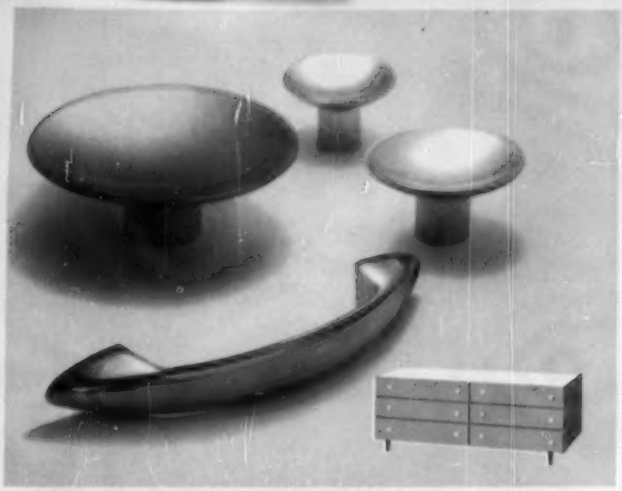


TORROID COIL ENCASED IN ALKYD. This coil is encased in alkyd putty material to prevent changes in electrical value of the component. In addition to alkyd's remarkable electrical properties, it molds at very low pressures allowing encasing of delicate inserts without damage.

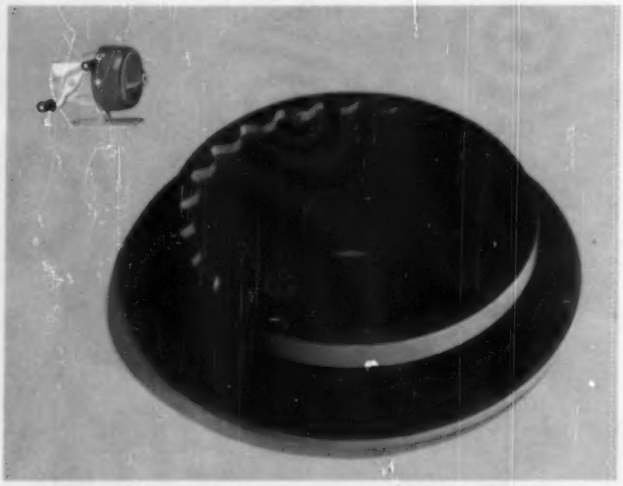


MOTOR COVER OF POLYESTER LAMINATE. Shroud for Johnson Sea-Horse Outboard Motor is match-metal-molded at less cost than metal counterpart. Rigid, resilient, and flexible formulations are available with special properties such as light stability, rapid impregnation, weathering resistance.

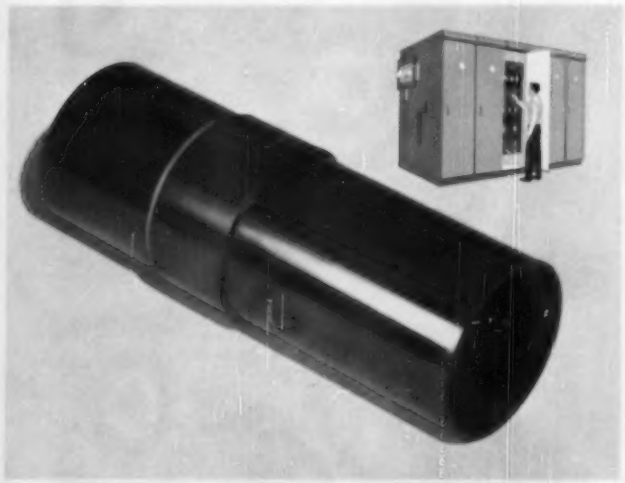
AIR-CONDITIONER PARTITION MOLDED OF PRE-MIX POLYESTER. Air conditioner by O. A. Sutton employs pre-mix partition in shape of Archimedes spiral. Special PLASKON Polyester Pre-Mix Resins permit the rapid molding of parts with varying thicknesses, intricate contours . . . with cost savings over conventional compounds.



DRAW PULLS MOLDED OF NYLON. Knobs and handles, injection-molded by Mirra-Cote, are metalized for lasting brilliance. The low-molding temperature of PLASKON Nylon minimizes thermal degradation and resultant gas evolution—produces void-free moldings. This nylon also provides excellent dimensional stability for critical tolerance parts.



REEL SPOOL OF MOLDED REINFORCED ALKYD. Glass reinforced alkyd easily withstands the tremendous pressure of wound nylon line during drying on this reel by Bronson Co. Alkyd offers very low mold shrinkage, excellent dimensional stability, low pressure and high-speed molding.



SLEEVE INSULATOR FABRICATED WITH PHENOLIC VARNISH. Designed by Allis-Chalmers Manufacturing Co., part utilizes flame-retardant PLASKON Varnish V-236. Burns only when exposed to very high temperatures (gas flame or electric arc) and extinguishes immediately upon removal of ignition source. V-236 laminates meet NEMA Grade XX.

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Du Pont announces . . .

New developments for molders and users of ZYTEL® nylon resins

NEW FORMULATIONS . . . Four new additions to the line of ZYTEL nylon resins offer improvements in specific properties to meet special needs:

a
ZYTEL 102X is a new color-stabilized resin. It is the whitest of the family of ZYTEL nylon resins and shows excellent color stability under prolonged or repeated heating.

b
ZYTEL FE-2281, a new hydrolysis-resistant formulation, has been developed to meet the extreme conditions under which this type of chemical change tends to occur.

c
ZYTEL 101-2315 is an improved ZYTEL 101. It offers a broad molding range, good flow and easy filling. This makes it possible to reduce temperatures and pressures required to fill a particular mold, frequently resulting in stronger parts with better color.

d
ZYTEL FE-2307 is a new composition having a lower melting point, lower processing temperatures, and greater flexibility than ZYTEL 101. Particularly suited for thick sections, it molds on fast cycles and has low mold shrinkage.

NEW JOINING TECHNIQUES . . . Difficult design and assembly problems may be solved by the use of self-tapping screws. Research studies by the Du Pont Sales Service Laboratory show that this type of fastener can offer substantial cost savings in joining and fastening plastic parts. It eliminates the molding of internal threads or a subsequent tapping operation. Studies cover torque requirements for driving the screws, permissible tensile loads with different sizes of screw, hole sizes and shapes for optimum holding power, time and temperature studies on fastener performance. The research is slanted especially to the requirements of the automotive industry. Information is also available on new, efficient spin-welding techniques of joining thermoplastic materials.

NEW SURFACE COLORING METHODS . . . New information is available on the surface coloring of parts made of ZYTEL. Cleaning of surfaces represents a negligible problem when no lubricants or mold release agents are used. Recommendations for correct primer coating and its application may be made. Topcoat adhesion of enamels is found to be excellent. The newer finishes, such as LUCITE® acrylic lacquers, are readily usable. Such painting is useful in putting designs on finished pieces, markings on business-machine dials and for similar applications.

For more information on any of these new developments send the coupon at right.

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E. I. du Pont de Nemours & Co. (Inc.)
Polychemicals Department
Room 4012, Du Pont Building, Wilmington 98, Del.

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*Name*_____ *Position*_____
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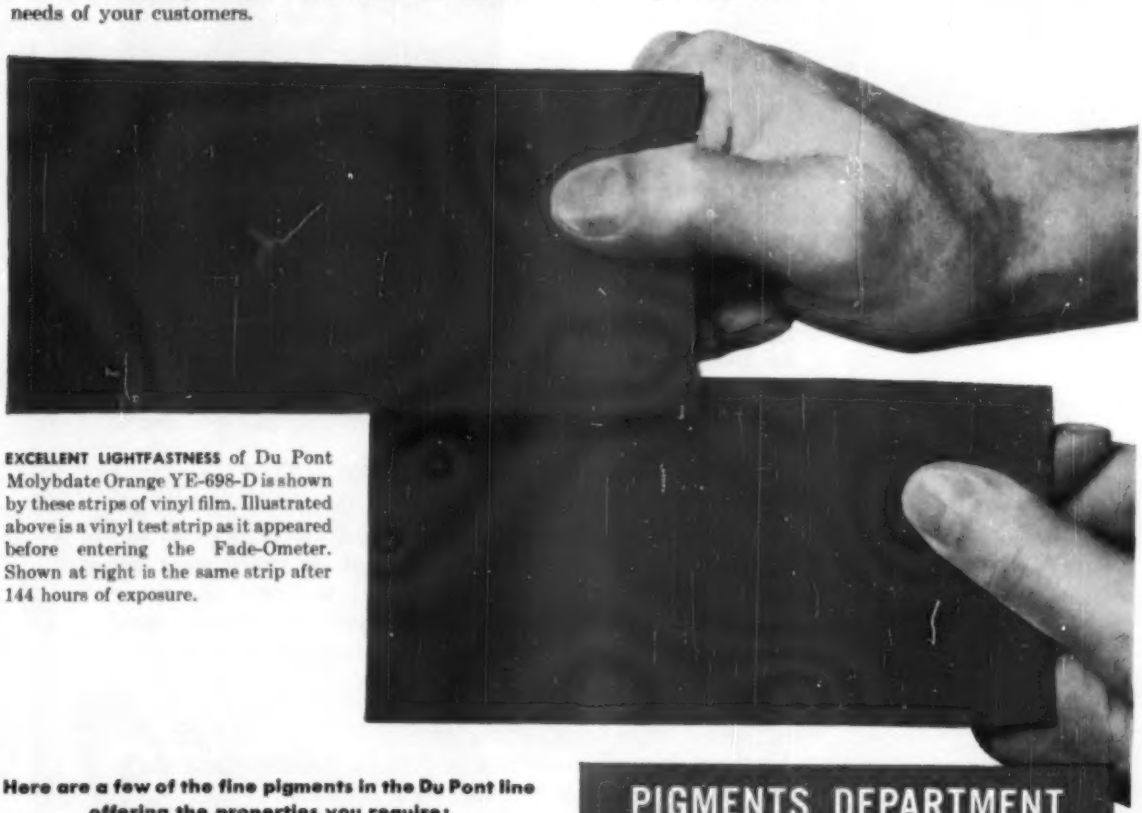
You capture the color appeal of the angelfish with lightfast Du Pont Molybdate Oranges and Chrome Yellows

Du Pont offers you an extensive line of Molybdate Oranges and Chrome Yellows for interblends yielding a wide shade range of opaque color in plastic systems. The red shade Molybdate Orange YE-698-D and the yellow shade YE-421-D provide excellent tinting strength . . . ease of dispersion. You can expect this same excellent performance in Chrome Yellow Light Y-433-D and Medium Y-469-D.

STRONG, BRILLIANT REDS—For ease of grinding and resistance to migration and crocking, use Watchung Reds in your vinyl systems. With a complete shade range to choose from—Watchung Red Light RT-618-D to Maroon RT-710-D—you can meet the most critical color needs of your customers.

LIGHTFAST GREENS AND BLUES—Yellow shade Monastral® Green GT-751-D provides excellent lightfastness, brilliance and crock resistance for your pastel-colored plastics. You can expect these same properties with Du Pont's Monastral® Blues.

COLOR STANDARDIZATION—You can rely on the batch-to-batch uniformity of all Du Pont Pigments to simplify color matching . . . with both pigment colors and Ti-Pure® titanium dioxide pigments. Technical assistance from Du Pont is always at your call. For information, consult your Du Pont Pigments representative, or write: E. I. du Pont de Nemours & Co. (Inc.), Pigments Dept., Wilmington 98, Delaware.



EXCELLENT LIGHTFASTNESS of Du Pont Molybdate Orange YE-698-D is shown by these strips of vinyl film. Illustrated above is a vinyl test strip as it appeared before entering the Fade-Ometer. Shown at right is the same strip after 144 hours of exposure.

Here are a few of the fine pigments in the Du Pont line offering the properties you require:

Ti-Pure® Titanium Dioxide
Green-Gold—Durable Organic Yellow
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Wheelco Capacitrols in both the 400 and 290 Series continue as the top choices in plastics instrumentation because they offer these "plusses" to both plasics machinery builders and users: (1) Advanced designs that improve operations and simplify maintenance; (2) skilled technical assistance from Wheelco's nationwide sales and service organization; and (3) training programs to assist your instrument technicians and supervisors.

Want more facts — your nearby Wheelco field engineer has them. Be sure to ask him for Bulletin F-6485, "Capacitrols for the Plastics Industry," too!

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Charles E. Rhine
Editor

EDITOR'S NOTEBOOK

SHOULD ENGINEERS WRITE?

As an engineer, your responsibility is to gain technical knowledge and apply it. Thus being at once both a source and a user of technical information, your job is dependent on the effective exchange of data. A more universal sharing of ideas and developments would minimize the duplication of efforts and increase the creative aspect of your work. Professional accomplishment is not enough—you must maintain an up-to-date knowledge by reading and listening, and conversely, you must write and speak about what you know.

A survey on the subject "Technical Writing by Engineers" was recently conducted by Michael K. Bonner, vice president, Harry W. Smith, Inc., and the editors of *Machine Design*. This survey was designed to gage the amount of writing being done by engineers and the management policies and opinions concerning technical communication. They found out that "the vast majority of firms are in favor of writing—and the vast majority of engineers do no writing!"

Mr. Bonner points out that the "burden of the technical-communication job is being carried by an extremely vocal minority. Nearly every engineering specialty has familiar authors and speakers who time and time again contribute technical information that is useful to other engineers. These men are only a fraction of those many engineers whose experience would be valuable to others in their profession."

It is pointed out in this survey that the engineer himself benefits by speeded advancement within his company and increased professional stature in his field; and that the engineer's company benefits by an enhanced engineering reputation as evidenced in the engineer's articles and papers.

Some of the observations made by Mr. Bonner are: 1) An average of only 5.3% of engineers write; 2) The engineer-writer rarely turns out more than two articles or papers in a year; 3) Most articles originated as an idea of the author with little suggestion from engineering management; 4) Article writing may be an indication of advancement potential; 5) Use of company time for writing is usually left to the judgment of the individual engineer-writer; 7) Almost all the companies are happy to help the engineer-writer with stenography, illustration and editing once he has decided to write; 8) An engineer-writer is usually rewarded by his superiors and company with recognition of some form; 9) Few companies pay the engineer-writer for an article; 10) While no engineering executives consider authorship the only reason for a salary increase, many feel it is an important contributing factor; 11) Many companies recognize that they should be doing a better job in technical communications.

The study also demonstrates how management can encourage technical writing and gives specific rules for building and maintaining a successful technical information program.

Copies of this eight-page report are available free. Harry W. Smith, Inc., has reprinted the study, and I have made arrangements for all SPE members desiring copies to receive them. Simply drop me a card or note saying you would like to have a copy of the report, "Technical Writing by Engineers."

Every SPE member owes it to himself to read this article and become acquainted with this aspect of his profession.

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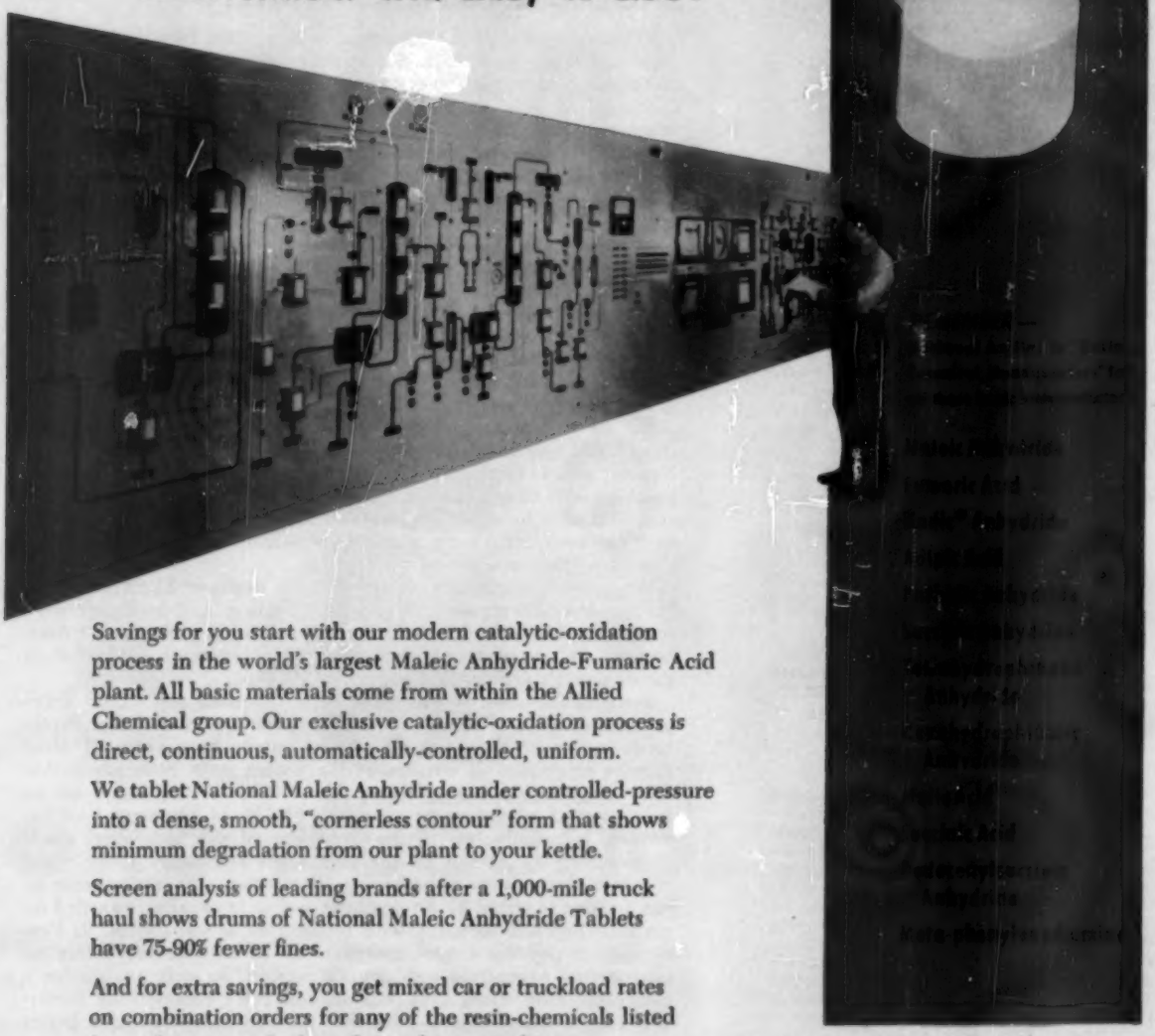

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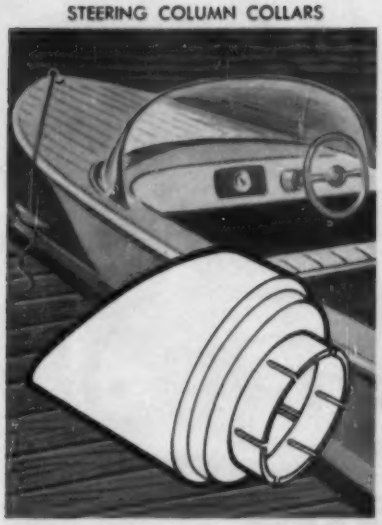

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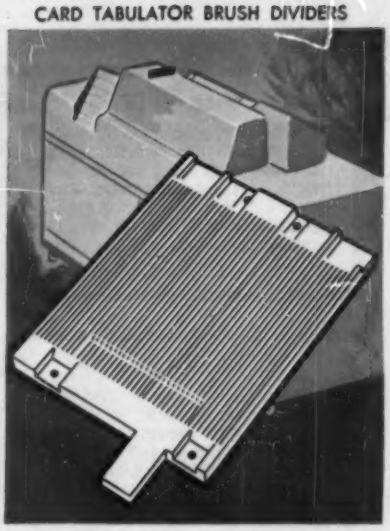
CARD TABULATOR BRUSH DIVIDERS



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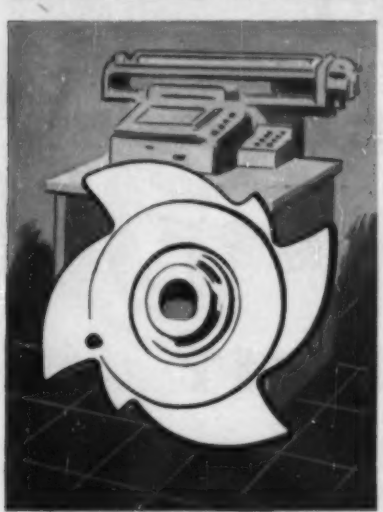

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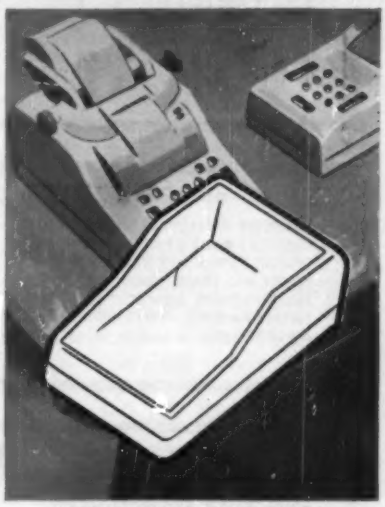

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A new extrusion resin — LUCITE 147 — This new composition provides sheets and shapes with improved resistance to attack by solvents used in paints, anti-stats and cleaning agents. Products are readily extruded with a new freedom from "fish eyes" and surface imperfections. Typical uses: Sheet for signs and fluorescent fixtures.

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The properties of Du Pont LUCITE are constantly being improved through research. For example, a new LUCITE 140, introduced two years ago, permits 20-30°F. higher cylinder temperatures in molding machines. The stability of LUCITE 129 has been increased in such a way that the material can be reworked several times without significant loss of the original color qualities. LUCITE compositions are preferred for their beauty and clarity, outdoor durability, light weight, shatter resistance, unique light-transmission properties. They offer a wide range of molding properties . . .

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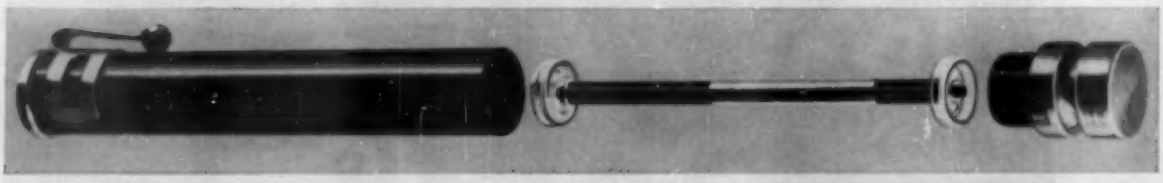


The most nearly perfect insulation material for electrical application known today is polystyrene. Electrical properties such as its high dielectric strength and its constant low dissipation factor make it ideal for the widely diverse applications discussed below.

Styron®, Dow polystyrene, plays an important role in the dosimeter, a device for measuring the amount of ionizing radiation. The dosimeter in the photograph is a simple electrostatic ionization chamber shaped like a fountain pen and worn in the pocket. The condenser is "loaded" with an electrical charge of known strength each morning before the unit is issued.

The presence of ionizing radiation, mainly gamma rays, causes the condenser to discharge. At the end of the day, the remaining charge is measured with an electrometer. The difference between the initial charge and the reading at the end of the day indicates the amount of radiation received by the person wearing the dosimeter. Styron plastic insulators isolate the condenser, effectively preventing loss of the initial charge.

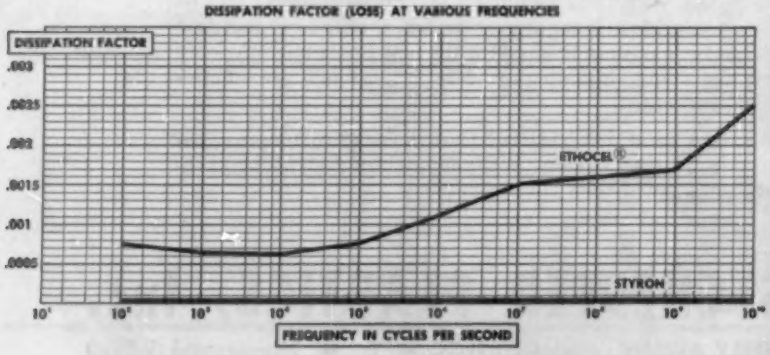
Electrical properties are one of many areas of investigation in which exhaustive Plastiatrics studies are being carried out by Dow. These studies survey every phase of plastics formulation, design, molding and finishing. Additional information on electrical properties as well as results of other Plastiatrics studies are available on request. Write to THE DOW CHEMICAL COMPANY, Midland, Michigan, Plastics Sales Department 1525F.

DOW EXPANDED POLYSTYRENE. Styrofoam® provides lightweight, highly efficient insulation for this microwave antenna mounted in a high tower. The lens, which is used to relay TV and telephone signals across the country, consists of metal strips completely encased by the Styrofoam. (Therefore, not visible in this photograph.) The essential property of the polystyrene foam in this application is its low dielectric loss factor. It holds the strips apart electrically, almost as if only air were between them.

POLYSTYRENE ELECTRICAL PROPERTIES

Property	Method	
Dissipation Factor	ASTM D 150-54T	.0002 to 10^{10} cps.
Dielectric Constant	ASTM D 150-54T	2.54 to 10^{10} cps.
Resistivity	ASTM D 257-46	10^{20} to 10^{22} ohm.cm.
Dielectric Strength	ASTM D 149-44	500 - 600 volts per mil at ⅛" thickness
Arc Resistance	ASTM D 495-48T	80 - 100 seconds

DISSIPATION FACTOR (LOSS) AT VARIOUS FREQUENCIES



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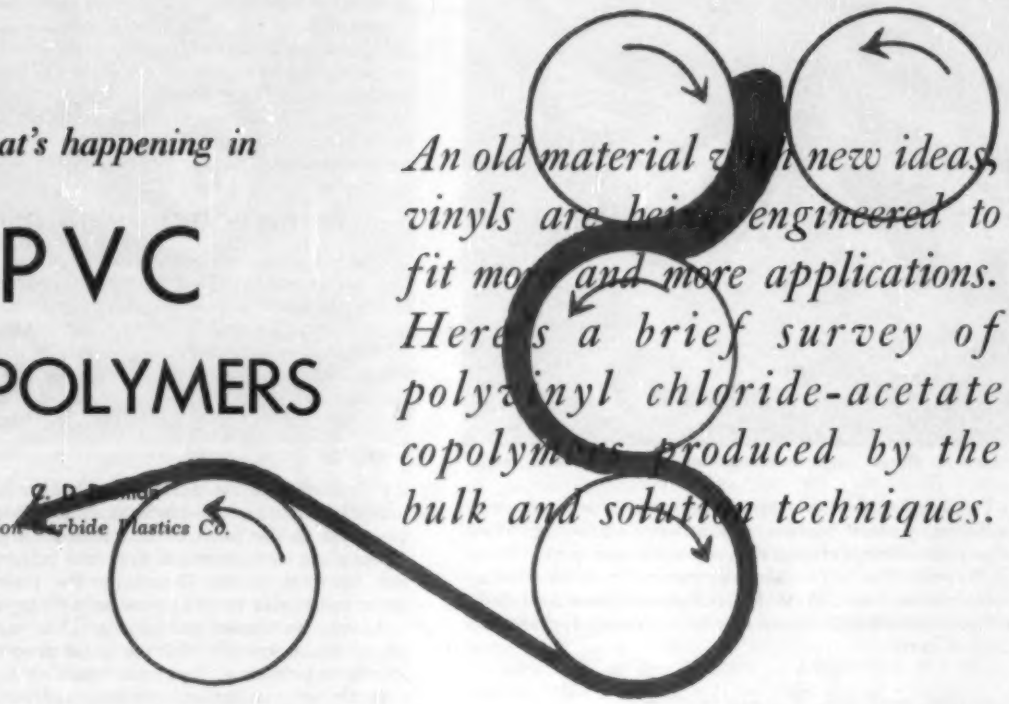
Volume 14, Number 12, December, 1958

What's happening in

PVC COPOLYMERS

Union Carbide Plastics Co.



An old material with new ideas, vinyls are being engineered to fit more and more applications. Here's a brief survey of polyvinyl chloride-acetate copolymers produced by the bulk and solution techniques.

POLYVINYL CHLORIDE copolymers are members of one of the most versatile families of plastics on the market today. For example, in their rigid form, vinyls appear as unbreakable phonograph records; in semi-rigid form vinyls serve in scuff-resistant flooring; in flexible form vinyls make raincoats and shower curtains; in liquid form vinyls serve as the base for protective coatings for hundreds of uses.

This versatility has prompted the prediction that vinyls may become the first two-billion pound plastic. Whether realized or not, the two-billion figure is extremely significant when one considers that although vinyl history dates back over 100 years, it wasn't until 1940 that the spectacular acceptance and growth of this polymer began. The growth pattern over the past four years has been equally spectacular. In 1954, 412 million pounds of polyvinyl chloride and copolymers were consumed. The following year showed an increase of more than 100 million pounds, with succeeding years showing further jumps of about 50 million and 80 million pounds respectively—which adds up to 647 million pounds sold in 1957.

As the trend in the volume of vinyls consumed has gone upward, an inverse movement in the price scale has taken place. In 1940, for example, vinyls sold at about 60¢/lb. whereas today the price is about 30¢/lb., or a 50% reduction.

This price and growth picture for polyvinyl polymers in general can be extrapolated to the specific materials which are the subjects of this paper—polyvinyl chloride copolymers, namely polyvinyl chloride-acetate resins.

This paper was presented before the New York Section of SPE.

Properties of Polyvinyl Chloride-Acetate Copolymers

Polyvinyl chloride copolymers were developed to overcome two limitations inherent in straight polyvinyl chloride resins—lack of flexibility and poor solubility. With the development of external plasticizers, flexibility difficulties diminished or disappeared. But in 1928 when the first patents were issued on the interpolymerization of vinyl chloride and vinyl acetate, the role of the latter material as an internal plasticizer was a significant one. The solubility factor, on the other hand, is still of vital importance. Straight polyvinyl chloride has very limited solubility in most solvents, whereas polyvinyl acetate exhibits rather extensive solution in many organic solvents. The degree of solubility of the copolymer resin can therefore be varied by altering the amount of polyvinyl acetate in the final compound. These copolymers may be dissolved in materials such as ketones, ethers, and chlorinated hydrocarbons.

Figure 1. Cured vinyl foam cushion is stripped from mold.

Polyvinyl chloride-acetate copolymers are odorless, tasteless, water-resistant and self-extinguishing. They also possess good dielectric properties and a low order of toxicity. The vinyl chloride content in these copolymers varies from 85 to 97%. Both solution and bulk polymerization techniques are used to manufacture this type of resin.

Solution and Bulk Polymerization

The first resins manufactured commercially were prepared by the solution polymerization technique, and this method is still in wide use today. Basically, this process consists of preparing a solution of monomer (or monomers) in a suitable solvent, which also contains a catalyst. This mixture is stirred in an autoclave, often under pressure and controlled temperature conditions. Slowly, the polymer builds up and becomes dissolved in the same solvent used to dissolve the monomers at the start. This results in a solution of gradually increasing viscosity. The reaction is stopped when the solution viscosity reaches a predetermined level. Often additional monomers are also added during polymerization and the process can become quite complicated when monomers having different rates of polymerization are being copolymerized. When the desired viscosity is obtained in the autoclave, indicating a certain molecular weight range, the "autoclave varnish" is passed on to precipitators where the dry resin is recovered by precipitation with nonsolvents. In some cases the resin may be redissolved and reprecipitated. The wet slurry is usually washed with water to remove catalyst traces and is finally dried in a hot air blast to produce a fine granular powder. This method of polymerization is inherently more costly than the bulk method because of the many steps involved, but through the use of ingenious engineering devices, it is still operated in competition with other methods and generally produces a superior product.

Bulk polymerization is probably the oldest polymerization method known, and also the simplest. By this method, the monomer (or monomers) is (are) simply stirred in an autoclave under proper conditions. The polymer formed eventually becomes a slurry of flaky or granular resin in the unused monomer. When the proper stage of polymerization is reached, the reaction is stopped by discharging the slurry with a consequent pressure drop which also serves to strip off unreacted monomer. Resin made by this process may or may not be washed before the final drying operation in a hot air stream. There are many problems connected with this polymerization method, not the least of which is that of removing the heat of reaction. Both the resin and monomers are poor heat conductors and this is complicated further by a tendency to build up layers of polymer on the walls of the equipment. This formation necessitates countermeasures, which further add to production costs.

FABRICATION TECHNIQUES

Like their parent polymers, polyvinyl chloride-acetate resins are modified by the addition of plasticizers, heat stabilizers, pigments, and fillers to obtain a variety of products. They are supplied as sheets, rods, tubes, granules, powders, and dispersions, and may be fabricated by standard molding, calendering, and coatings techniques.

Coatings

Polyvinyl chloride-acetate copolymers have been particularly useful in the coatings field. When these resins are used in the form of solutions in organic solvents, either clear or pigmented, they are referred to as solution coatings resins. Generally the resins are of the lower molecular weight, more soluble types.

As was mentioned previously in discussing solubility, all of the polyvinyl chloride copolymers can be dissolved in ketones and some are soluble in aromatic hydrocarbons or in ketone-aromatic hydrocarbon mixtures rich in the hydrocarbon component. Solids contents at workable solution viscosity range from 15 to 40%, depending on the molecular weight of the resin. With most of the resins in this class it is necessary to add about 10 to 30% softener or plasticizer based on the dry resin weight; this addition results in improved physical properties. Plasticizers generally are very high boiling ester compounds and for practical purposes may be considered as nonvolatile and therefore as permanent components of the film. The most widely used plasticizer for vinyl chloride resins is di 2-ethyl hexyl phthalate.

Films produced from the copolymer resins exhibit excellent toughness and flexibility, good aging and weathering, and abrasion resistance. Chemical resistance is excellent; films are not attacked at normal temperatures by alkalies, mineral acids, alcohols, greases, oils and aliphatic hydrocarbons. The degree of water resistance is high, and permeation by water vapor extremely low. Higher polyvinyl chloride content increases chemical and solvent resistance, and higher molecular weight increases the abrasion resistance, but these property gains are achieved at the expense of solubility. Other film properties include low order of toxicity, complete absence of odor and taste, flame resistance, water-white color, good clarity, relatively high refractive index, and permanent thermoplasticity.

These properties make coatings based on polyvinyl chloride-acetate resins extremely suitable in hygienic applications, areas requiring extreme flexibility or formability, chemical plant and equipment coating, outdoor

Figure 2. Molding microgroove records from undiluted resin.

uses, and heat sealing applications. One of the first, and still one of the important uses for vinyl coatings is as lining for beer cans, where the coating serves to protect the product from contamination by the metal. From this start vinyl coatings spread into all sorts of can and closure uses in the food, toiletry and cosmetic industries. It is only the existence of a relatively low temperature softening range, a consequence of their thermoplastic nature, that prevents vinyl resins from taking over the food-can coating field completely. This limitation has encouraged research on the combination of the properties of vinyl resins with thermosetting materials in an attempt to extend the usable temperature range.

The very property which limits vinyl usage in cooked-food processing is a boon in other food and packaging applications. Due to their thermoplastic nature, vinyl coatings readily heat seal, thus providing an economical means of sealing in modern high-speed packaging operations. For example, a problem in the aluminum-foil packet industry was solved by the use of vinyl coatings. Aluminum foil cannot be heat-sealed; but when a coating of polyvinyl chloride copolymer is placed on the foil, the packet can be readily sealed by application of heat.

Another large and growing market for vinyl solution coatings is that of chemical-resistant and maintenance paints. Here the properties of chemical inertness and weather resistance are the attractive features. Coatings based on vinyl resins have revolutionized steel ship-bottom painting and their use is still increasing rapidly in the field of protective paints for steel structures. This type of painting has been proven time and again to be capable of effecting enormous savings in the overall maintenance cost of chemical plants and other industrial installations having severe corrosion or weathering problems. In this field particularly, the vinyl butyral resins—cousins of the polyvinyl chloride-acetate copolymer—are important as the means for securing tight adhesive bonds of vinyl films to metal substrates on air drying only. These primers, known as wash primers, are discussed in the trade literature of the past few years.

Vinyl solution resins have not yet found wide acceptance in such important coatings markets as appliance and automotive finishes even though many of the inherent properties suit them admirably for these applications. One of the main reasons for this situation is appearance. It is generally difficult to pigment vinyls satisfactorily so as to produce high gloss, mirror-like finishes. However, recent developments in the field of improved pigmentation show promise of greatly expanding the use of vinyls in the "appearance" markets.

Molding

Although polyvinyl chloride-acetate resins (solution polymerization-type) are used in only one molding application—unbreakable sound records—this application accounted for about 6% of the total polyvinyl resin consumption in 1957.

As early as 1931 the value of fabricating plastic records from a vinyl resin base was recognized and proved. The high fidelity of reproduction, the intrinsic low noise level, and the resistance to wear of the vinyl records were markedly better than shellac records. Furthermore, the inherent strength of these records over a wide range of temperature and humidity changes for the first time enabled manufacturers to label records "unbreakable."

Although these superior qualities were valuable in the production of better regular groove 78 rpm records, of greater importance was the fact that vinyl resins made possible the advent of microgroove, long-playing type records. Because of the molding characteristics of vinyl resins, records can now be produced with as many as 300 grooves/inch without reduction in reproduction quality. These same molding characteristics are also extremely important in the newer stereophonic recordings.

The quality of records may be established at will by altering the formulation. For best tonal quality and break resistance, an undiluted record compound should be used. With the addition of fillers and/or extenders, cost can be reduced, but at some sacrifice in quality. For regular groove records, highly-filled vinyl resin formulations are customarily used, while for microgroove records, particularly those designed for high-fidelity reproduction, unfilled or slightly-filled vinyl resin compounds (from 90% resin content and higher) are considered desirable. The requirement in the latter case for higher resin content is a result of the narrower wall thickness incurred by the increase in the number of grooves per inch. Because of the excessive thermal treatment to which the resin is subjected both during the preform fabrication and the molding processes, stabilizers such as the basic salts of calcium and lead are added to retard thermal decomposition of the resin.

Basically, the resin formulation is processed into a sound record in the following manner. The proper quantities of resin, stabilizer, extender and/or filler, lubricant and colorant are preblended until homogeneous, hot compounded, and then shaped into biscuit-like preforms. These preforms are then preheated, either in an oven, on a steam table, or electronically, before being introduced into the compression press. Where granular material is used, it is plasticized in a heated cylinder and then placed on stampers for molding. Semi-automatic or fully automatic compression presses, of the tilting head or vertical closing type, are customarily used. The mold is of the open flash type. The optimum molding cycle for phonograph records will depend upon

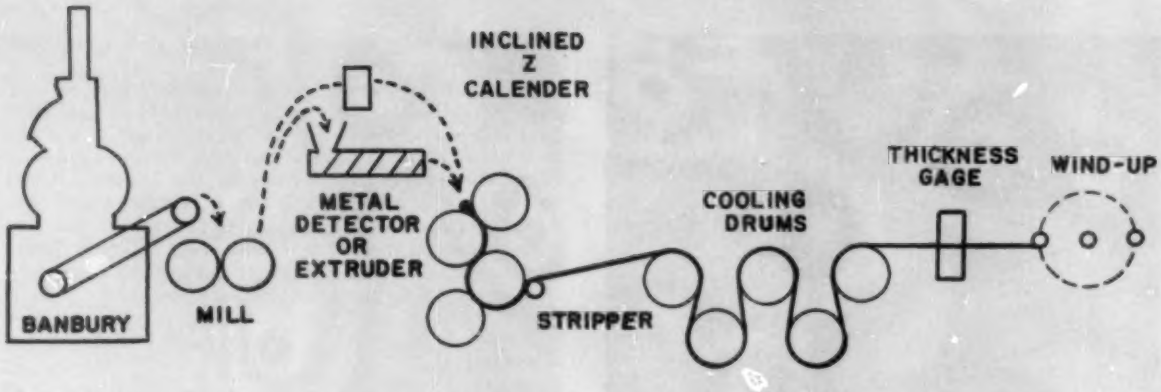


Figure 3. Calender layout for vinyl film production.

several factors, notably record diameter and thickness, groove shape, and equipment setup. Representative molding cycles for preforms heated to 120°-125° C range from ½ to 1 minute.

Calendering

Another large area of use of polyvinyl copolymer resins is in calendered materials. Both flexible and rigid vinyl can be successfully calendered. Film and sheeting calendered from polyvinyl chloride and copolymers have shown remarkable growth since their introduction in 1939. By 1957, yearly production of vinyl film and sheeting reached 165,000,000 pounds. In addition, polyvinyl chloride copolymers used in fabric treatment and floor coverings totaled 137,000,000 pounds. This wide acceptance is also demonstrated by such diverse applications as household items—furniture covers, shower curtains, housewares, upholstery, flooring, and closet accessories; leisure items—luggage covering, inflatable toys, and pool liners; industrial uses—credit cards, milk bottle caps, luminous ceilings, food wrap, skin packaging, and automotive fabrics; apparel—rainwear, handbags, and shoes; and agricultural uses.

Polyvinyl chloride copolymer film has good dimensional stability, wide range of heat stability, low water vapor absorption, good chemical and abrasion resistance, and practically no gas permeability. As can be seen from the aforementioned applications, the film is designed for use where highest clarity in gloss, chemical inertness and resistance to moisture vapor and common gases are required. The material is not recommended, however, for applications requiring low temperature impact strength.

Essentially, calendering is a manufacturing process whereby a compound is fed to rotating rolls which compress it to the thickness of the space between the rolls. Calendering of plastics was first accomplished using standard three-roll rubber calenders. Later a fourth was added, which gave an "inverted L" or "Z" configuration, depending on the placing of the rolls.

In operation, a continuous feed of fluxed compound is maintained in a bank between the top and the offset roll. As the rolls revolve, the fluxed material passes between the rolls and is then conveyed over a second series of rolls for cooling. By adding embossed steel rolls between the calendering and cooling phases of the operation, it is possible to obtain nearly any surface pattern. The quality of the product can be further improved by varying such factors as temperature, roll speed, and roll separation. From the cooling rolls the materials are wound on cores, and boxed for shipment or storage.

Figure 4. Close-up view of calender cooling rolls.

Conclusion

The foregoing description of processes and techniques presents a factual review of the highlights concerned with vinyl resin production and fabrication. The details of each phase discussed could very well comprise chapters or small volumes of their own. However, for reference purposes summaries such as this frequently prove to be a useful source of information. General knowledge of vinyls, as well as the methods employed to make them can be obtained in short order. In addition, resin characteristics and relative property information is available for end products formed by any of the fabricating techniques described. Anyone familiar with the diversity of vinyls and their subsequent forms is also aware of the effort expended to keep abreast of the innovations—both materials and techniques—that are constantly appearing. With an understanding of the basic fundamentals, as presented herein, it is hoped that the detailed data can be more quickly understood.

★ ★ ★

COLLEGE COURSES IN HIGH POLYMERS

A Report on the American Chemical Society Symposium

Jesse H. Day
Ohio University

"Education in Plastics" was the subject of a symposium held at the American Chemical Society National meeting in Chicago September 7-12. The symposium was sponsored jointly by the divisions of Polymer Chemistry and Chemical Education.

The symposium, which was mainly concerned with the teaching of polymer chemistry, provided an interesting insight into the kinds of instruction the universities are providing.

College instruction in high polymers may be divided into three classes.

1. Instruction in the undergraduate program.
2. A survey course in the graduate program.
3. A series of courses in the graduate school.

Undergraduate Programs

Most schools feel that there is no place in the undergraduate chemistry curriculum for a specialized course in high polymers. Some schools recognize the importance of the subject by using the chemistry and properties of high polymers to illustrate standard course material.

For example, at the University of Wisconsin the regular elementary physical chemistry course includes an introduction to the x-ray diffraction patterns obtained on plastics to demonstrate how these patterns can be used to determine the degree of orientation of a substance. The theory of rubber elasticity is used to illustrate a point in thermodynamics, and the osmotic pressure measurements of polymers are used to illustrate some ideas in the thermodynamics of solutions. The laboratory work includes work on systems of high polymers, such as measurements of osmotic pressure and viscosity.

A number of chemistry departments are spending more time in the regular organic chemistry course using high polymer reactions to illustrate what is meant by free radicals, free radical reactions, and polymerization. The products formed from free radical reactions are also used to illustrate the concepts of stereochemistry.

The Graduate Program

The most usual situation is for the university to offer a single one-semester course in high polymers at the graduate level. Most large universities have such a survey course, and many of the smaller colleges as well.

In some schools which offer only a survey course there may be a regular polymer chemist on the faculty, in which case research and further instruction in polymers will be available to the interested student who wishes to specialize.

There are still relatively few schools which offer a series of courses in polymers, and it is probably fair to say that no two programs are exactly alike. In general such schools are larger schools which are close to a metropolitan area where the manufacture of plastics is a large industry. For example, the University of Akron offers three basic lecture courses in polymer chemistry; organic chemistry with laboratory, physical chemistry with laboratory, and a lecture course in the mechanical behavior of polymers. It is their intention to stress the broad underlying principles and to minimize memorization of specific factual data.

The Brooklyn Polytechnic Institute actually has a separate polymer division within the chemistry department. They offer an extensive series of courses on the graduate level, including the organic chemistry of large molecules, the thermodynamics of polymer solutions, polymer kinetics, and theory of mechanical properties. This is one of the most extensive series of polymer courses in this country.

The Department of Chemistry at Duke University offers a survey course in polymers which is required of all graduate students in the fields of organic and physical chemistry. Their intention is not to train polymer chemists as such, but to provide a basic working knowledge of polymers useful for all chemists. They recognize especially that the course provides not only information about high polymers but especially an opportunity for the student to broaden his knowledge by providing applications in a new field of principles learned in kinetics, thermodynamics and organic reactions.

College-Industry Courses

Many of the more extensive graduate programs in high polymers are provided in night courses at schools which draw students from industry in addition to their regular graduate students.

One of the better known series of courses is offered at the University of Delaware in their extension division, under the direction of Fred W. Billmeyer, Jr., who is associated both with the University and with Du Pont Company. They offer a series of 4 one-term graduate level courses; organic chemistry of high polymers, fibers and elastomers, physical chemistry of high polymers, and polymerization kinetics. The majority of the students are employed by industry. Reading for the courses is in the basic textbook of polymer chemistry by Billmeyer, supplemented by reading assignments in more detailed works and in the original literature. To date, they have granted over 35 master and doctoral theses dealing with polymers. Billmeyer notes that while one might hope that ultimately much of the descriptive material now taught in the polymer

courses could be incorporated into the under-graduate curriculum, this modification does not appear probable in the near future.

The Overall Picture

John L. Kice of the Department of Chemistry of the University of South Carolina did an excellent job of summarizing the overall picture. He noted that undoubtedly a major deterrent to more extensive instruction in the elements of polymer chemistry is the simple fact that there are relatively few true polymer chemists in academic institutions. Yet, in view of the tremendous industrial importance of polymers, it is important that any undergraduate curriculum in chemistry include at least some elementary polymer instruction. At the University of South Carolina they include a good deal of basic high polymer chemistry in their undergraduate organic course, including specific polymers of particular interest. A specialized polymer chemist is not necessary in order to make a presentation of polymer chemistry on the undergraduate level. At the graduate level the school which lacks a polymer chemist faces a much more difficult problem in attempting to provide adequate polymer instruction.

For the smaller school there seem to be two courses open. One is to include high polymers in the various courses as examples and illustrations of principles. The difficulty here is that not all of the teachers have a good background in macromolecules, and as Mr. Kice says, "Until there is more insistent pressure for widespread instruction in macromolecular chemistry, the activation energy for any form of professorial self-instruction is liable to remain rather high." The alternative to this is the polymer survey course which does require someone who has been extensively exposed to polymer chemistry. Kice makes the valuable suggestion that schools which do not have polymer chemists, but which are near an industrial research laboratory having a polymer research group, might well arrange for one of the research group to offer a polymer survey course for the edification of both students and faculty. He further suggests that if a school is not so located, that funds might be found to send an interested young faculty member to one of the intensive summer polymer courses offered by one of the institutions which specializes heavily in polymer research. He further suggests that those who are teaching at universities where adequate polymer instruction is presently available should strongly urge all students who contemplate a teaching career to get at least some grounding in polymer chemistry while they are in graduate school.

Summary

Certainly not all of the colleges offering instruction in plastics were represented at the symposium, and especially one thinks of such well known plastics programs as those at Princeton University, the Lowell Institute of Technology, Newark College of Engineering, and others. The symposium did, however, offer a fair cross-section of the situation within the chemistry departments of most universities across the country. They have recognized that instruction in high polymers is a desirable and even necessary addition to the regular chemistry curriculum. In those schools which do not have a graduate program, there is usually a real effort to incorporate some instruction in polymers into conventional courses.

Those schools with a graduate program will usually offer at least a survey course in high polymers when there is a man on the faculty competent to offer such a course. It is still only the exceptional school which offers more than one course in high polymers. The very fact that this symposium was held at all is adequate proof that the universities realize the necessity of providing some instruction in high polymers and their interest in seeking the best way to do this.

There are probably means by which industry could help, in addition to the usual financial support of polymer research. They might contribute fruitfully in making available to teaching faculties such teaching materials as samples of plastics and textual information on the properties and uses and methods of fabrication, especially of the newer plastics. Some regular program for providing a tour lecturer to speak for one or two hours on high polymer chemistry to chemistry classes would also provide a worthwhile service to the colleges. An interested company could invite a limited number of faculty, who are teaching or are interested in teaching polymer courses, to spend a summer working in the company laboratories. Another way to broaden college teaching of polymer courses would be to offer support to enable faculty of smaller colleges to attend an intensive polymer course given during the summer at one of the larger institutions. Such broadening of basic polymer instruction would eventually be effective in reducing the length of in-plant training now necessary.

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Graduate Plastics Program Fellowships

Princeton University is offering a program of graduate engineering study and fundamental research in plastics. The program leads to the degree of Master of Science in Engineering, and is particularly suited to chemical, electrical and mechanical engineers, and to chemists and physicists.

Instruction covers basic theory and properties, evaluation, production, fabrication, design and application of materials, as well as chemistry of plastics. Program includes lecture and laboratory classes, and contact with industrial plants representing various interests of the plastics industry.

Fellowships with stipends of from $1500 to $2100 plus tuition and fees, are available. Opportunities for employment as half-time Research Assistants at $2100 per academic year are also available to students not on fellowships.

Applicants for admission must hold a Bachelor's degree in engineering or physical science from a recognized institution and must meet general admission requirements of the Graduate School of Princeton University.

For further information regarding curriculum, fellowships, research assistantships and application forms, write to Prof. Louis F. Rahm, Director, Plastics Laboratory, Princeton University, Princeton, N. J.

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How to Speed Up Older Injection Machines

You can get faster, more efficient operation from your old injection molding machines. Here are a few suggestions on how this can be accomplished with a minimum amount of investment, and at the same time reduce maintenance costs.

A. R. Morse

Injection Molders Supply Co.

AS SUPPLIERS of injection machine replacement heating cylinders, one of the most common inquiries we get is this, "I have an old 19—Model Press. What can I do to make it as competitive as possible with new machines?"

Clean Filters

Actually there are many steps that can be taken to improve production from older presses. Basically there are two types of injection machines in use today: the toggle or mechanical and full hydraulic clamps. Let us consider the mechanical type first. These presses use vane type pumps mostly of Vickers manufacture. For a modest investment new rings, vanes and gaskets can be installed in any Vickers type pump.

Maximum delivery rings should always be specified. New pump gaskets both on the cartridge and the shaft, properly adjusted as to tension will often improve pump delivery and pressure.

Oil intake filters should be inspected and either entirely removed or replaced with new full volume types. Lint plugged intake screens can cut up to 2-3 seconds off a cycle. Mere cleaning is not enough. Intake filters must often be burned out to remove lint and fine particles. Vacuum gages on the intake line often reveal a starved pump. If the clean or new intake filter does not put the needle down to a safe 0-5 lb. intake suction range, it may be that the high pressure pump intake should be repiped so it sucks directly from the tank instead of from the low pressure line as a bleeder. Separate pump intakes are definitely recommended and repiping of older presses is urged if any starving or restrictions are found in the pump intake lines.

Heavier, Cooler Oil

Many presses of the toggle type can be speeded up by several other methods. A heavy oil instead of a light or medium should be used. This helps overcome internal leakage or blow-by from normal wear in valves which otherwise slows press response. It also prevents the oil when slightly overheated from thinning with consequent loss of speed and lubricating properties.

Many older machines have water coolers now partly plugged with hard water deposits and running at lowered efficiency. Line thermometers should be installed and coolers thoroughly cleaned and inspected, so that guesswork as to the temperature is eliminated.

Larger Water Lines

A common cause of press slowdown not readily recognized has been increase in total plant water demand or installation of evaporative cooling systems. Thus ample tap water previously available at 50-60°F is replaced by closed circuit cooling water with a variable temperature that runs about 10°F over ambient air temperature.

To handle evaporative systems, plant water lines must often be nearly doubled in size so that increased volume of flow is available to compensate for the higher water temperature. Failure to repipe and take the other steps described here can add two to three seconds to the cycle.

On older presses the circuits were often laid out so that the oil not going to the work cylinders was returned to the tank through the oil cooler. Thus the faster these presses are run the less oil is available for cooling, and serious overheating can occur, limiting the minimum cycle. Repiping of the oil cooler so it can pass more oil is vital in getting more speed out of such circuits.

The addition of an extra water-type cooler, the use of the new air type air cooler as an auxilliary unit, and change to the newer 4-pass type heat exchanger therefore will definitely help maintain correct oil viscosity necessary for high-speed operation. Maximum oil temperature should not exceed 100°-120°F. The cooler the oil is the better, especially since our next recommendation is to step up normal line pressure from 1000 or 2000, to 1200 or 2400 lb. This increases oil temperature but press response is much more brisk. Control of injection pressure is reestablished on many jobs at higher line pressures which would otherwise operate simply with maximum injection pressure. Higher line pressure definitely means more Btu's added to the oil, so the counteracting steps suggested here should always be taken.

Extra Pump Sets

Use of an extra 5 or 10 hp or even larger pump set unit pipe into the existing circuit will also help speed up a press. Press speed is a direct function of horsepower and one reason new model machines cost more and go faster is that larger motors and bigger or double pumps are used. Investment in pump sets is one well made, where top speed at low cost is desired. A historical review of almost any line of presses clearly reveals this trend to higher and higher horsepower over the years, so that modernization must include consideration of an extra pump set if older presses are to equal today's speeds.

Repiping

Repiping of older machines is also suggested. First full size flexible

hoses are used to by pass restrictions often found in older fixed telescope type connections. Then the return line from the injection cylinder should be disconnected from the tank and repiped with the proper checks so that oil from either side of the cylinder feeds to the other side. Thus all the new oil from the pump has to do is to supply enough volume and pressure to move the piston.

We are often asked why gas type accumulators do not give good results on injection machines. The answer is that the pressure drop occurs just at the critical moment of injection when more pressure and more speed are needed. Possibly a circuit could be devised where an accumulator started the plunger travel but was cut out just before the moment of injection so full positive pressure was available for those seconds where the mold filling is actually occurring. A mechanical or weight-loaded accumulator, except for its size, is the ultimate answer to our problem of injection press speed vs. horsepower costs. With central systems many European plants do have old presses that can cycle faster than almost any self-contained ones used today in America. A simple weight-loaded accumulator is definitely something to consider if speed at low cost is desired.

Tuneups

Retuning hydraulic systems is seldom done, but much speed can be gained by simply resetting cushions in 4-way valves and cylinders for snappier action. Many circuits incorporate various restrictions in the pilot lines and these should be located and their need and purpose reevaluated.

Simpler manifolding of older presses can eliminate many feet of old style piping and greatly decrease press down time caused by leaks, or hammering causing line breakage. Manifold plates can be obtained from various sources such as valve manufacturers or even from press manufactures, by selecting a suitable panel from a newer machine and ordering it as a spare part. Such manifolds on older machines simplify piping, cut down time from leaks, and reduce maintenance costs.

Simplification of piping, manifolding and installation of full size or oversize oil lines can add up to 2 seconds reduction in minimum dry cycle time. In addition, such modifications allow the press to run cooler and hence faster.

Rewiring

Rewiring of presses and changes in limit switch arrangement will often help speed up older machines. For example, elimination of the booster limit switch is suggested. The full volume full pressure solenoid that cuts in both high and low volume pumps at high pressure is now activated several seconds earlier by the die closed timer. Thus the dies close faster and the plunger or injection ram takes off faster. The booster is then not released till just after the mold is filled. New booster clocks with sensitive settings up to 10 seconds are needed but are well worth the modest cost.

The use of both high and low volume pumps at top line pressure setting, heats up the oil and the motor. Special rewinding of some motors may be required to stand the heat rise of the temporary overload occasioned by the longer use of the low pressure relief valve cut out, or booster. The investment however is a good one, even if a whole new heat-resistant motor were called for of higher horsepower and with the special heat-resistant winding to take the 3 to 10 second intermittent 100% overload.

Obviously, this change in the booster system must be preceded by rewiring of the injection end so that the plunger returns all the way and then advances to a ready position half way forward, all during the die closed period. This conversion is easily made with proper limit switches on any older machine.

Modernization of pilot line piping is also a good move. Installation of electrical or push button controls and use of new 4-way valves with integral solenoids greatly simplifies pilot piping and give a faster action than older styles and of course reduces down time from line breakage.

Adequate power lines to the press from the transformer must be installed to take the overload mentioned, and to avoid the pull-down in speed of pump commonly found in plants with inadequate electrical service. Full size electric lines to rewired presses permit a gain of from ¼ to ¾ of a second per cycle, as well as more efficient plasticizing because full voltage is delivered to the press.*

On newer model presses elimination of the low pressure die closing safety feature will often cut 1 or 2 seconds from the cycle, sometimes more than paying for the risk to the mold.

New lighter safety gates that are easier for the operator to open and shut can often cut up to a second off the cycle, and should be considered in many cases where original equipment is unhandy or slow.

Die Open Time

Mold open time is the one variable that cannot be controlled except on full automatic setups. A signal light and timer to pace the operator and call attention to excess die open time has been tried. The device is not a popular one, but it does even out production on a group of machines running on identical work, and call attention to operators that are likely to lag.

Reworking of a mold to eliminate the need for a mold release is often a most important step in speeding up a cycle. Application of any kind of parting agent must be done while the mold is held open, and often is a most costly makeshift.

Full Hydraulic Presses

On full hydraulic machines with rotary piston type pumps, a relatively costly pump overhaul is about the only available recourse the molder has. This type of pump, especially on older machines delivered either a high volume of oil at low pressure or a lower volume at higher pressure as the pump stroke decreased with rising pressure. Thus the injection ram actually slowed down during the injection stroke instead of speeding up as on vane type systems with boosters.

If the shift in pressure demand by the heater varies, plunger speed also varies during actual injection, and sometimes streaks can be seen in molded articles because plunger speed was not constant or actually increasing for that critical moment of injection. Consultation with the pump manufacturer is suggested as circuit and pump modifications are sometimes possible which increase volume of pump delivery at high pressure. This is a vital step in improving performance of full hydraulic machines. Use of auxilliary vane type pump sets will also help increase and steady injection speeds. Other suggestions regarding oil and repiping given above also apply to full hydraulic machines.

In appraising older full hydraulic machines, the condition of the main clamp cylinder can often be the deciding factor in whether or not to modernize. If the cylinder has

*Heater efficiency drops with the square of voltage lost. This important factor is often overlooked in analyzing press speed-ups.

cracked and been welded, or if the press has required frequent replacement of the main clamp cylinder, the molder must weigh costs of downtime resulting from the often extended delivery on this major casting, as well as cost of the part itself. Since most presses seem to be "Repeaters" in this regard, if the press history is good, chances are usually excellent that the cylinder will continue to give good service almost indefinitely.

Hydraulic circuits of full hydraulic presses and pump details have undergone far more radical modification and improvement than circuits on toggle type presses. The result has been more rapid obsolescence of older types, and greater difficulty in adapting movements such as quieter pumps and overhead oil tanks. Noise alone has often been cited by molders as the main reason for not investing in overhauls of older hydraulic clamp machines.

Heating Cylinders

Modernization of the injection end is possible only with installation of new extra capacity heaters. Extra wattages used on such chambers demand that contactors be changed to carry the new load safely. Replacement chambers of various designs are now available from several sources. Thus presses whose speed has been limited by lack of plasticizing capacity (pounds per hour output, as contrasted with ounces per shot used in rating presses) can now be operated at maximum dry cycle speed.

In some cases press bases can or must be lengthened to accept newer more modern heaters. In others, redesigned larger diameter oversize heaters of modern design can eliminate any need for extensive rebuilding of the injection end of the press.

Use of Powerstats or Variacs on front zone bands offer a low cost method of adding a third zone of heat control on older presses. These controls are always recommended to allow nozzle zone heat to be gradually reduced after heats are up. Where such bands are hooked into the front zone or are under off-on controls, no reduction of heat in the forward end of the chamber is possible, greatly slowing sprue setup and lengthening cycles.

Modern Heater Bands

Check of old or used heater bands reveals that in time heat output falls off due to partial oxidation of the elements. New bands of the same or even higher wattage can be ordered in some cases. In others, higher wattages cannot be justified beacuse the wall sections of steel and plastic are not properly proportioned to dissipate and absorb the additional heat. Rezoning of the heat and use of flange heaters on rear flanges of older chambers sometimes increases output.

In the specific case of 16-oz. HPM's for example, of '46 to '52 vintage 13⅜-in. or 13½-in. diameter bands of 2,600 watts can be installed on the bolt circle flange to overcome heat loss into the casting.

Substitution of new water cooled plungers for old solid plungers also helps because the water cooling on the feed sleeve can be discontinued and heat applied instead. Provision to prevent the plunger from rotating must then be made to prevent water lines from being torn loose.

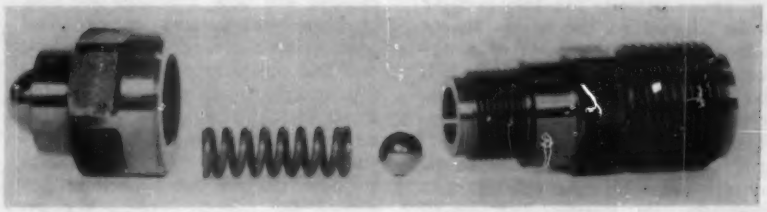

Figure 1. Removable tip ball shutoff nozzle minimizes residual pressure on material left in heater at fast cycles. Two flex lead heater bands 1½" ID x ½" under Powerstat or Variac control are used to regulate nozzle heat.

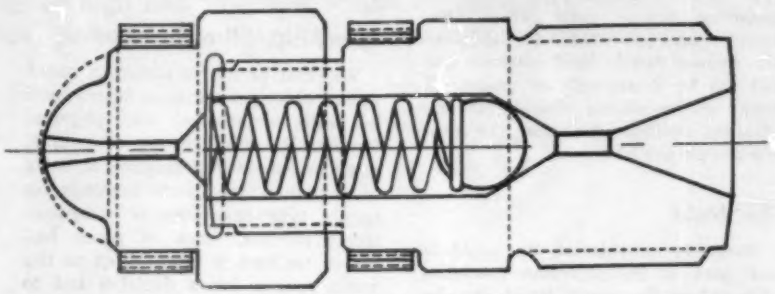

Figure 2. Section of typical stock model ball shutoff shows heater band locations and detail of construction. Manual adjustment of band heats permit operator to minimize stringing under all conditions.

Larger and Smaller Plungers

Bulk factor of many plastics materials often limits the use of older machines on full capacity shots. This can sometimes be corrected by installation of oversize plungers and feed cylinders. Use of specially balanced heating chambers of improved design can then minimize the effects of the injection pressure so lost. In general, 17,000 psi on the face of the plunger is the minimum suggested. Below that pressure setting molding problems begin. Then molds must be reworked, gates and runners enlarged, in order to run at the unusually low injection pressures. On polyethylene and with fluffy regrounds produced by dull grinder blades or old style grinders, larger plungers are often vital to restore full press capacity, along with needed changes in the feeding system itself.

Many older presses have been quite successfully converted to *lower* capacity by use of smaller injection plungers. Usually such machines are used on extremely high pressure jobs with acrylic, butyrate or Kel-F where the injection pressure is run up to 35,000 or even 40,000 psi. Again, heating cylinders with internal material passages balanced to the new plunger size can permit such presses to compete quite profitably with new, special purpose machines.

Nozzle Heat Controls

Use of pyrometer-type controllers on nozzles is generally not recommended because of difficulty and costs of locating and maintaining a thermocouple in the crowded nozzle area. Proper physical appearance of the sprue—a nice clean cut off—is a far better criterion of proper nozzle heat setting than a pyrometer reading taken in degrees. This is true because the instrument reading often bears little if any relation to the actual temperature on the nozzle.

If space permits the thermocouple to be located on the nozzle tip or extension itself the costs of a pyrometer hookup can be justified. If the thermocouple fitting must be located in the nozzle hex, a pyrometer should be used for a reference reading only, and the actual control done by the setting of a Powerstat or Variac. The on-off feature of even the best proportioning pyrometer cannot compare to the steady heat put out by the other type of controller, especially in the sensitive nozzle zone where the heater band is so close to the plastic. Proper nozzle heat controls can cut up to 3 seconds or more off many cycles where obsolete or inefficient devices now cause the nozzle to run too hot.

The Mold

Properly considered, the mold is not part of the injection machine, but unless the mold itself can be run faster, there is little point in considering speed up of the machine. If the mold cannot set up the part faster, then any press, old or new can still run the job with the same profit and without the investment in press modernization.

Four steps in connection with the mold itself can be taken to speed up setting of the part which is usually the longest part of any cycle.

First, elimination or shortening of the sprue by means of special heated extension nozzles is suggested. Proper nozzle design will permit quicker freezeoffs. Ball shutoff nozzles with integral reverse tapers are now available to assist in faster sprue setting. They minimize residual pressure on material left in the nozzle throat. All such nozzles should of course have their own controls independent of the heater itself.

Faster Cooling

Relocation and enlargement of mold water passages is urged for faster cooling. Where this is impractical, yearly reboring of passages to remove scale and rust and calcium deposits that gradually insulate water passages is suggested. Tests show that cycles must often be increased up to 2 to 3 seconds over a year's time by insulation growing inside mold passages by gradual deposition of rust and scale.

And finally use of mold chillers which circulate water and antifreeze solutions down to 20°F will cause faster setup and often make faster cycling possible. Portable chillers are now available for this purpose from several sources. The application however, is a demanding one and ordinary commercial cooling equipment is generally inadequate for chilling molds. Burst coils, compressor failure, and lack of adjustable controls plague general purpose chillers not especially designed for injection plant service. Combinations of commercially available components seldom will perform in this application, so specially built units are suggested.

Speed Up — Pro and Con

Whether or not to invest in speed ups of older machines is determined by both economical and physical factors. Press condition of course, must be considered. In general, costs of renewing pins and bushings on toggle type machines is comparatively modest. Lack of space between tie bars is often given as the main reason for a decision not to invest in speed ups because the older press will not handle larger more modern molds.

In general, more success is had in speeding up old style toggle-type machines than in full hydraulic types. This is reflected in the used market prices of the two classes of presses. The fact that many more 10- to 20-year-old hydraulic clamp machines than toggle type are being scrapped each year, also points to the fact that investment in speed up in the latter often can be justified whereas the full hydraulic types cannot be modernized as easily or as cheaply.

Who Can Help

Outside help in modernizing presses is often difficult to obtain because the machinery people are naturally more interested in selling new presses than in speeding up old ones. Hydraulic equipment manufacturers, the oil salesman and the representatives of concerns that supply oil coolers, often can be of great assistance. But in general, the only successful way to speed up an older press is by diligent study of it as suggested above. If the press condition is good it will definitely pay to modernize because of skyrocketing costs of new presses.

Several independent concerns have the large physical facilities and engineering know-how to take in older injection machines and rebuild them. This service includes complete dismantling, cleaning, replacement of worn parts and rewiring.

Another approach to the problem of press speedup and rising new machine costs is that offered by a new prime mover unit. The prime mover consists of tie bars, toggles, platens, bases and oil cylinders, with or without a heat chamber. The molder then may proceed two ways. First he may purchase and install all piping, valves, pumps, motor, and wiring which will be uniform with those already in his plant; or he may remove them from a worn out 8- to 16-oz. machine of any make and install them on a new prime mover unit. The prime mover concept is an entirely original one that will appeal to any molders who wish to standardize press components.

An experienced maintenance man can work wonders with an old, slow machine, and the writer is acquainted with many good plant engineers who could do well for themselves by setting up an independent maintenance service to overhaul and modernize presses. This is a field entirely untouched and one urgently needed by many shops whose presses are in poor condition because they lack skilled care.

References

1. "Hydraulic Maintenance in Injection Plants" by A. R. Morse, *SPE Journal*, November, 1951-p. 2 ff.
2. "Injection Speeds, Injection Pressures" (The Injection Molderscope) *SPE Journal*-May 1952.
3. "Souping up the Reed 8", A. E. Campi, *Plastic Industry Magazine*, December 1952-p. 8 ff.
4. "Modernizing Old Injection Machines" by A. R. Morse, *Plastics Technology*, September 1955-p. 478 ff.
5. "Appraising Used Injection Machines" (The Injection Molderscope) *SPE Journal*-June 1956.
6. "Hydraulic Systems in Injection Machines" by Larry Hahn, *Applied Hydraulics*, April, 1948-p. 19 ff.
7. "Effects of Thermocouple Location and Control of Higher Wattage Bands in the Injection Industry" by R. W. Channel (Wheelco Instruments Co.) and A. R. Morse, *Plastics Technology*, June, 1955-p. 277 ff.
8. "The Injection Molding of Derating Materials" by J. C. Stokes (Perry Plastics Co.) and A. R. Morse, *SPE Journal*, Vol. 6, No. 2, February, 1950-p. 3 ff.

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How Plastics React Under Rapid Loading

High loading rate data are determined by the actual performance of tests in the 5-15 milliseconds to fracture range giving a comparison of mechanical characteristics of high and low rate values on cellulose acetate, cellulose nitrate, nylon, polystyrene, polyethylene and other materials.

G. R. Rugger
E. McAbee
M. Chmura
Picatinny Arsenal

PLASTICS are more rate sensitive than are some other materials. This, coupled with the fact that many Ordnance Corps items are subjected to very high rates of loading, makes is necessary to know just how these materials will behave when loaded very rapidly. To date, there have been three alternatives. One has been to base predictions of acceptability on data obtained at low rates of loading. This process has been misleading. Another alternative was to fabricate each end item from all available plastics and try each material under use conditions. This proved to be very expensive and time consuming. To avoid the above two processes, efforts have been made to substitute a more easily controlled variable, such as temperature, for the rate. While such a procedure will give qualitative results, the values obtained have not been sufficiently precise for design use.

In recent years, several Laboratories have attempted to obtain data at rates comparable to those achieved in use. The Ordnance Corps' Plastics Laboratory was one of the Laboratories which attempted to do this. A high rate tensile tester was designed and constructed by the Plastics Laboratory of MIT. This work proceeded under the direction of Professors A. G. H. Dietz and F. McGarry. After receipt of the tester, several modifications were made. These changes were incorporated to achieve faster rates, to facilitate testing, and to increase the accuracy of the results obtained.

Results and Discussion

The values obtained at both low ("static") and high rates are shown in Table I. In reviewing these data, emphasis in most cases has been placed on the strength, work to produce yield, and modulus. The first property was chosen for emphasis for the obvious reason that high strengths are normally desirable. Emphasis was placed on work to produce yield for two reasons. One was that most materials are of limited usefulness after they have started to flow. The other was that the work to reach this point (the area under the load-deformation curve up to the yield point) is one indication of toughness or ability to absorb energy. The modulus was chosen since, for some applications, the stiffness of a material will be a critical factor in material selection.

The data shown are the first obtained. Similar data covering all representative plastics will be obtained in a continuing program.

Three cellulose acetates were tested. These were compounded to represent a general purpose, a heat resistant, and an impact resistant material. The data indicate that when a strong tough material is required, the heat resistant grade is superior to the other two grades. The strength of this material is greater both at low and high rates of testing. On the basis of work to produce yield, it is approximately twice as tough as the impact resistant grade. These data indicate that the Izod impact test, which is normally used to measure toughness, does not completely characterize energy absorption ability. They also show that while elongation at low rates is essentially equal for all three grades, an appreciable difference in elongation at yield point appears at higher rates. If stiffness is critical, the general purpose grade is superior although again this would not be evident from the low rate data.

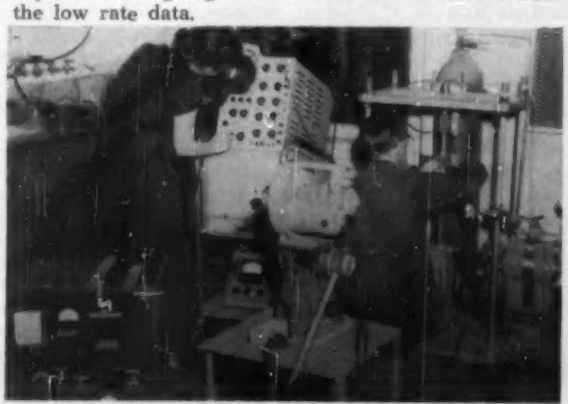

Figure 1. High-rate tensile apparatus showing Fastex camera set-up.

This paper was presented at the 1958 Design Engineering Conference of The American Society of Mechanical Engineers.

TABLE I

	Yield Strength, psi	Elongation at Yield, %	Work to Produce Yield, ft-lbs/in³	Maximum Tensile, psi	Elongation at Break, %	Work to Produce Failure ft-lbs/in³	Modulus psi x 10³
Cellulose Acetate, General Purpose							
Low Rates	4060	2.25	4.8	4710	27.5	86.8	296.
High Rates	10400	4.2	24.7	10750	13.4	144.	450.
Cellulose Acetate, Heat Resistant							
Low Rates	4380	2.32	5.3	4500	28.8	93.3	311.
High Rates	11400	7.0	46.4	11400	24.2	231.	360.
Cellulose Acetate, Impact Resistant							
Low Rates	1410	2.4	1.7	1410	38.8	37.3	98.
High Rates	4900	5.5	15.0	5050	26.0	97.8	155.
Ethyl Cellulose, Hard							
Low Rates	5160	3.2	9.2	5580	11.9	45.8	303.
High Rates	—	—	—	11500	5.0	31.2	392.
Ethyl Cellulose, Soft							
Low Rates	3930	4.0	9.8	4490	12.1	31.6	224.
High Rates	9400	6.0	31.6	9400	13.4	89.6	380.
Cellulose Nitrate, General Purpose							
Low Rates	4380	3.4	9.7	5260	32.9	120.	311.
High Rates	11600	4.9	33.1	11600	17.3	142.	410.
Cellulose Propionate, Soft							
Low Rates	2090	2.4	2.6	2090	25.3	35.4	128.
High Rates	5500	6.0	36.4	5610	28.5	122.	205.
Cellulose Propionate, Hard							
Low Rates	4580	3.1	7.0	4850	56.0	185.	240.
High Rates	—	—	—	7970	2.3	15.6	330.
Polystyrene, Unmodified							
Low Rates	—	—	—	7450	1.9	6.8	485.
High Rates	—	—	—	9605	2.2	10.6	570.
Polystyrene, Rubber Modified							
Low Rates	3950	5.3	4.0	3950	5.3	13.	243.
High Rates	6350	2.3	7.7	6350	21.1	104.	360.
Polyethylene, Branched							
Low Rates	1300	11.2	8.8	2010	152.	180.	41.2
High Rates	1990	16.0	22.1	—	—	—	42.5
Polyethylene, Linear							
Low Rates	2570	17.1	29.5	3520	28.7	76.8	107.
High Rates	5500	6.9	24.7	5500	13.7	54.9	215.
Polytrichlorofluoroethylene							
Low Rates	5350	7.1	20.5	5350	139.	498.	223.
High Rates	10650	12.4	68.3	10650	55.3	456.	240.
Polyvinylidine Chloride							
Low Rates	3670	12.5	28.	3670	23.3	45.8	107.
High Rates	—	—	—	8810	11.3	31.0	205.
Chlorinated Polyether							
Low Rates	3950	18.5	46.9	4020	62.5	187.	99.
High Rates	8150	9.5	34.2	8420	10.1	50.3	190.
Polymethyl methacrylate, Cast							
Low Rates	9720	5.8	33.3	9720	6.7	41.	434.
High Rates	—	—	—	14000	3.0	15.5	680.
Nylon, General Purpose							
Low Rates	7000	30.3	140.	9900	293.	1580.	147.
High Rates	11100	24.0	191.	11100	127.	934.	360.

A hard and a soft ethyl cellulose were tested. While the hard grade was appreciably stiffer at low rates, the moduli of the two grades were nearly equal at high rates. The hard material did not exhibit a yield so a comparison on that basis is impossible. On the basis of work to produce failure, the soft material appears much better. Thus, in contradiction to the low rate data, the soft grade is nearly as stiff and is much tougher than the hard grade. Strengthwise, the harder material is stronger at both high and low rates.

Only one cellulose nitrate was tested. While this material is normally considered rather tough, these data show that the increase in toughness with rate is not as evident here as with some other materials. However, work, strength, and stiffness all increase with rate.

The cellulose propionates tested show, as did the ethyl celluloses, that the elongation at break is decreased markedly for the hard formulation while the soft formulation is actually more ductile at high rates than low rates. However, contrary to the ethyl cellulose tested, the soft grade did not become as stiff as the hard grade at high rates.

An unmodified polystyrene did not exhibit a yield at either high or low rates. However, the load-deforma-

tion curve obtained at high rates indicated the approach of a yield point. This was unexpected and leads to conjecture as to whether or not even higher rates would result in a true yield. However, at the rates attained in this program, the straight polystyrene was still a strong stiff material with little ductility.

The rubber modified polystyrene shows the same trends as did the unmodified polymer. Strength, elongation at break, work and modulus all increased with an increased testing speed, although the values obtained show that the added rubber increased toughness at the expense of stiffness.

Some differences in the behavior of branched and linear polyethylenes were brought out in this program. Low rate tests indicate that the linear material is much tougher up to the yield point. However, at high rates, approximately equal toughnesses are shown. The data obtained in this program also show that the stiffness of the linear material increased with rate whereas the branched material has equal moduli at the two rates. The extension of the branched material was too great to be obtained with the procedure used.

Polytrichlorofluoroethylene is a tough material as shown by the work to produce yield. While not as tough on an absolute basis as is nylon, the increase from the low rate value is over 300% while for nylon, the increase is only approximately 33%. Stiffness is moderate and is not greatly affected by rate.

Polyvinylidine chloride was stronger and stiffer at high rates but the work decreased.

A chlorinated polyether showed the normally expected increase in strength and decrease in extension. This made the material less tough and approximately twice as stiff.

Cast polymethyl methacrylate showed up as having the highest tensile strength of the material tested. It was also extremely stiff at both high and low rates. The energy absorbing ability is very low, however.

The nylon tested had a rather low increase in work to produce yield as the rate was increased. While it is still the toughest material tested on an absolute basis, the trend would lead to speculation that the advantage of this material might disappear if tested at a sufficiently high rate. Normally, when nylon is tested at low rates, it passes through a yield point, flows, and then rises to an ultimate strength which exceeds the yield strength. This has at times been attributed to orientation. However, at high rates of loading, the yield and ultimate strengths are equal. It may be that the duration of the test is too short to allow orientation.

As stated before, these data were obtained as part of a continuing program. In addition to their value to the design engineer who has an end item which will be subjected to loading in comparable times, they suggest other programs to confirm or refute hypothesis advanced as a result of these data.

Equipment

The equipment used for the high rate testing is shown in Fig. 1. In essence, a piston which is actuated by compressed nitrogen gas is attached by means of a grip to one end of a standard ASTM Type I tensile specimen. There are two alternative routes for this gas. The highest rates are achieved by passing the gas through a solenoid to the piston by the shortest possible route. Slower rates may be obtained by the use of an alternate route containing both a solenoid for the rapid release of the gas and a needle valve to control the rate of flow.

The piston which the gas actuates is contained in a cylinder which has slots machined in the sides. These

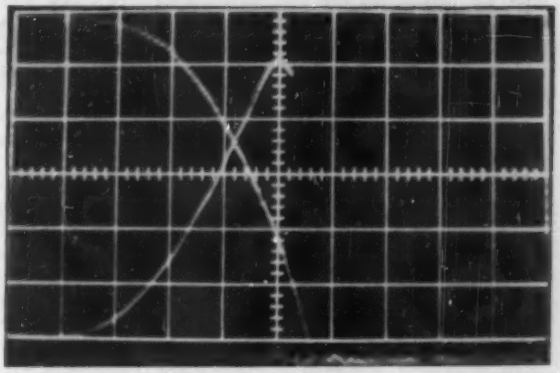

Figure 2. Displacement-time curve (upper) as recorded by potentiometer type pick-up device.

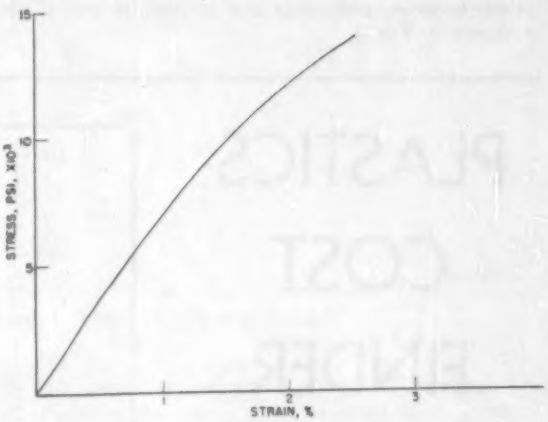

Figure 3. Typical stress-strain curve as constructed from load-time and deformation-time data.

slots are so located that at first, all of the gas is confined by the piston cylinder walls. After the specimen has broken and the upper face of the piston has passed the tops of the slots, gas begins to escape through the slots. When the piston has traveled seven inches, it starts to compress the air in the closed bottom part of the cylinder so that an air cushion is formed to brake the motion of the piston.

The load versus time information is obtained by means of SR-4 strain gages attached to a cylindrical weigh bar. The weigh bar, in turn, is attached to the upper portion of the specimen by means of the upper grip. The output voltage of these strain gages is amplified and fed into an oscilloscope, where a load-time trace is recorded by Polaroid camera.

The measurement of strain offered several difficulties. The original idea was to attach SR-4 strain gages to the specimen and to thus pick up changes in output voltage as the strain increased. However, due at least in part to the small cross-sectional area of the original specimen used and to the effect of the solvents in the adhesives, strain measurements which were in error by 12 to 90% were obtained.

A second approach was to attach a rack to the lower grip and a pinion to a ten turn helipot. The movement of rack actuated the pinion affixed to the shaft of this pot. The change in resistance of this helipot with grip displacement was fed to the oscilloscope and resulted in a time-displacement curve. However, as shown in Fig. 2, the displacement lagged behind the

load by approximately one millisecond. This lag was not constant so that a simple correction factor could not be applied. In addition, the cross head motion rather than the extension in the gage length was being recorded.

It was decided that the only reliable method known was the photographing of the separation of gage marks. Gage marks were applied to the specimens and their separation as the load was applied was recorded by high speed photography. Timing "pips" were also placed on the film so that displacement versus time was recorded.

The black box in the foreground of Fig. 1 controls the sequence of the triggers used. It first starts the camera and turns on the flood lamps so that the camera is up to full speed and the lights have reached maximum intensity before the testing machine is automatically triggered. Suitable delays are incorporated so that the oscilloscope trace and the Polaroid camera are triggered to catch the action. With load-time pictures and displacement-time films, the values can be converted to stress and strain and plotted. A typical plot is shown in Fig. 3.

In this set of experiments, a nitrogen pressure of 1500 psi was used. This gave breaking times of from 2 to 15 milliseconds, depending upon the characteristics of the material being tested. A check on the modulus obtained with the high rate tester was made by dynamic means as described in the May 1956 *ASTM Bulletin*, ("A Vibrating Reed Test for Plastics" by Stephen Strella.).

The low rate data with which the high rate data are compared were obtained using an Instron Universal Testing Machine.

This machine had previously been modified as described in the January 1957 *ASTM Bulletin* ("A Mechanism to Operate a Tension Tester at Constant Strain Rate" by Stephen Strella). These data are of interest in their own right since they were obtained at constant strain rate rather than the more conventional constant crosshead separation or constant rate of load increase.

★ ★ ★

PLASTICS COST FINDER

R. L. Stern
Chemical Superintendent
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The nomograph illustrated here is a practical means of finding the cost of plastics materials. It is based on the simple relationship that material cost in cents per pound divided by specific volume in cubic inches per pound is equal to material cost in cents per cubic inch. The density values corresponding to a given specific volume are included as density is a more common standard than specific volume. The density scale, of course, has a non-linear relationship with its reciprocal, specific volume.

Since this is a basic type nomograph, it is used accordingly. A straight edge joins the two known quantities, density and cost per pound, and the value in question is taken from the intersection of that straight line and the third scale.

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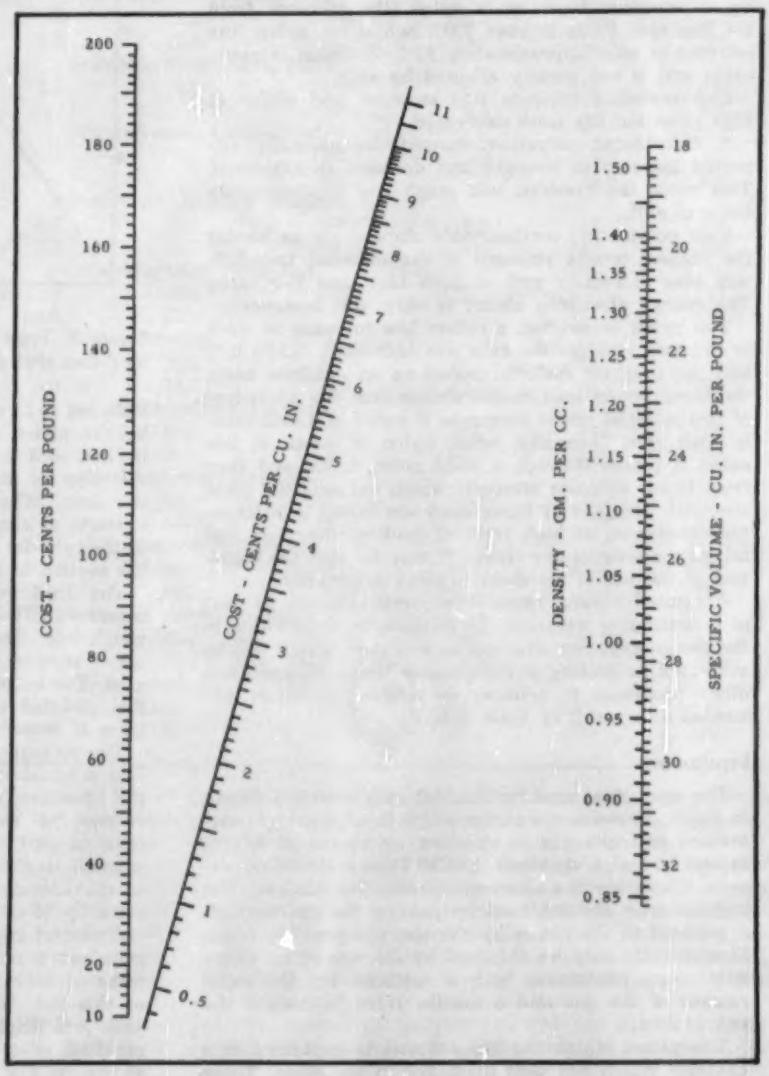

Tailoring Polymers for Electronics

Silicone alloys formulated to meet specific dielectric and insulating properties give electronics engineers superior compounds to serve the growing microwave industry.

Charles L. Petze, Jr.

Delaware Research & Development Corp.

THE MICROWAVE electronics industry has become one of the most important industrial fields in the United States. Current annual sales of microwave equipment have been estimated at $500,000,000, still increasing at a high rate (Ref. 4). This equipment is important not only in military endeavours, but is finding more and more civilian uses. The short, high frequency radio wave that travels in a straight line with the speed of light already has provided some 50,000 miles of voice communication links in the United States and a coast-to-coast relay network in Canada.

California has been said to have an economy centered on the automobile; automatic vehicular traffic control radar is rapidly becoming a reality. This is no device to apprehend the speeder; it is a traffic controller to expedite vehicle flow and, some of us expect, one of these days to be an effective accident preventive.

The microwaves, which range in frequency from a few hundred megacycles per second to upwards of 50,000 or more, act in many ways like visible light except that materials opaque to light may be transparent to the microwaves. It is here that the chemist finds a new opportunity to be of service. So does the molder and extruder of polymer compounds.

A dielectric material may be defined as an electrical insulating material in which electrical energy may be stored. While it may be a gas, liquid or solid, this paper is concerned only with dielectrics used in the solid state. It describes some of the results obtained with new, property-controlled dielectric materials: the silicone alloys developed by Delaware Research.

The Lens Antenna

Sir Oliver Lodge, in 1889, machined a lens from a slab of hardened pitch. While he had no control over its dielectric constant or of loss tangent, he found that this lens did have a beaming effect on the radiation from a spark-gap oscillator (Ref. 3). He probably was the first man to use a lens as an antenna.

It is the function of the antenna to direct the radiated power efficiently in a selected direction. A useful beam is obtained when the spherical wave of a point source is converted into a plane phase-front, the plane wave traveling in a direction normal to the phase-front. A parabolic reflector will effect this change. As shown in Fig. 1, so will a lens, when properly constructed of a material having the requisite dielectric properties.

This paper was presented at the Regional Technical Conference sponsored by the Golden Gate Section of SPE.

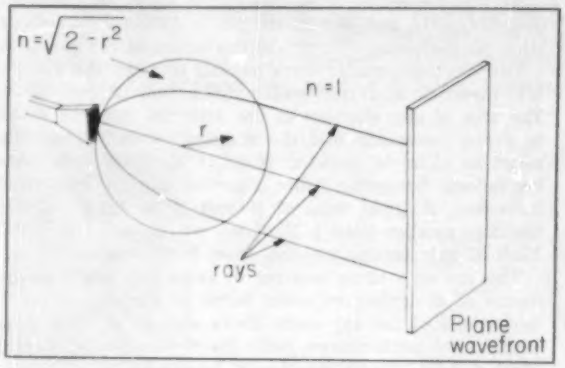

Figure 1. Action of a lens antenna.

In this case, the refractive index, n, is equal to $\sqrt{2-r^2}$, being the radius which is equal to or greater than zero but does not exceed one. This is the formula for a two-dimensional lens, the index of refraction varying with the radius.

Clerk Maxwell, in 1860, studied theoretically a lens in which the refractive index of the dielectric material was a continuously varying function of position (Ref. 2). The resulting lens shape, derived by a transformation of the ray-paths on the surface of a sphere, provided a means of scanning 180° of arc in a two-dimensional, variable index lens. Some 80 years later, R. K. Luneberg proposed that a 360° scan could be obtained if a lens could be built that was circularly or spherically symmetrical about a central point with the refractive index dependent only upon the radial distance from the center (Ref. 5).

No one, so far as I am aware, has produced a dielectric material and formed it into a two-dimensional lens or a spherical lens in which the value of dielectric constant varies continuously with the radius. In order to construct a lens, we have had to employ to date a stepping technique. The dielectric constant, and consequently the dielectric material, is uniform throughout the volume of each step, which is a disc or ring for a two-dimensional lens and a spherical core or concentric shell for a spherical lens.

The value of refractive index and—when the permeability of the material is unity—of dielectric constant for each step of a spherical lens is:

$$n^2 = \epsilon = 2 - \left(\frac{r}{R}\right)^2$$

where r is the radial coordinate for that step and R is the radius of the lens.

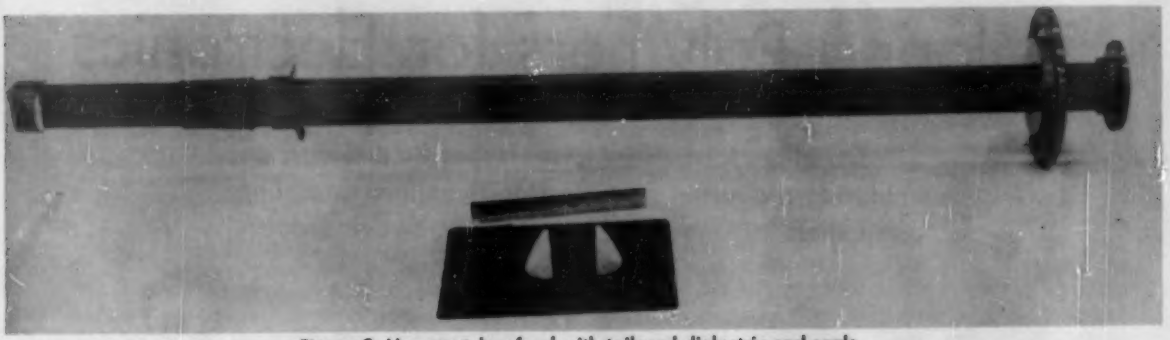

Figure 2. Hop-stretcher feed with tailored dielectric end seals.

At the lens edge or periphery, a dielectric constant of 1 (equal to air) is desired. For a standard Luneberg lens, the dielectric constant at the center of the lens is 2.

The electromagnetic wave passing through the dielectric material must not suffer diffraction or resonance. The size of any element of the material must be small to avoid resonance and the spacing between elements must be close to avoid diffraction, the size and space limitations becoming more rigorous as the frequency increases. A good rule of thumb is to keep discontinuities smaller than 1/32 of the wavelength; at 10,000 Mc/sec. this means smaller than 1 millimeter.

The use of a large number of steps and small increments of dielectric constant holds to a minimum perturbations of the ray-path; there should be little degradation of performance from the continuously varying ideal system. Focussing should be good.

A loss tangent not in excess of 0.001 holds the total lens loss to less than 0.5 decibel (db) at 9,375 Mc/sec. (3.2 cm. wave-length) or less than 2.0 db at 35,000 Mc/sec. (8 mm). In radio repeater links for communications networks, the saving of one decibel can mean a saving of $6,000 to $10,000; the repeater stations can be spaced farther apart (Ref. 6).

Both two-dimensional and spherical Luneberg lenses have been constructed and used in microwave systems. Some spherical lenses have been as small as 8" or less in diameter. Recently, lenses having diameters of 12' and of even more than 100' have been designed. Rapid and wide angle scanning, without the problem of off-axis performance, becomes a reality. Only the compact, light weight feed need be moved.

But the heart of the matter is the availability of light weight, low electrical loss, weather resistant, variable index of refraction dielectric materials. They also must be produced routinely in commercial quantities with firm control of property reproducibility. They must be formed economically into the required isotropic structures. The burden of proof has been and continues to be on the chemist and molder.

A New Antenna Feed

The antenna and its feed are among the most vital components of microwave systems. The expanding use of microwaves in communications, particularly in the many heavily populated areas where interference between installations already has become a problem, places greater demands upon the performance of the antenna and upon the ingenuity of its designer. The user of the telephone wants a crystal-clear "line" with a softly-spoken word heard distinctly. The operating company requests broader band antennae, lower side-lobes, better cross-polarization isolation, all without any sacrifice in gain.

More efficient primary feeds to illuminate a parabolic reflector can be obtained by pressurizing the interior volume of the feed; moisture is kept out and attenuation held to a minimum. To hold these pressures, the aperture of the feed must be sealed. It is easy to do the sealing job but it is another matter to obtain a material that has as well the best value of dielectric constant and low electrical loss, that will retain these properties when exposed to the weather, to abrasion by particles of sand or dirt driven by the wind. Unless it also has and holds a high value of electrical surface resistance when wet with rain or high humidity, poor performance, if not failure, of the communications system can result.

Antenna feeds have been designed by choosing for the end seal a standard dielectric and then designing the electrical elements around this more or less tolerable material. The Gabriel hop-stretcher feed (Fig. 2) was done in the opposite manner.

A configuration was chosen to give the best gain-bandwidth characteristics without much attention to the dielectric properties of the end seal. The units were designed for a telephone relay system operating between 5925 and 8100 Mc/sec. The impedance plot prior to determination of the best dielectric end seals indicated a spread in voltage standing wave ratio (VSWR) of 1.38.

Computations based on theory indicated that, for this feed, an aperture end seal made of a material having a dielectric constant at 6000 to 8000 Mc/sec. of not more than 1.12 and a loss tangent of about 0.001 should be satisfactory. It was known, however, that the dielectric constant of a light-weight silicone alloy material could be varied in small steps over a wide range and end seals having any preferred value thereby obtained, routinely in production. Consequently, a series of seals was prepared and evaluated in the actual feed. Fig. 3 illustrates the relationship between VSWR and frequency for three pairs of these seals varying in $\varepsilon'/\varepsilon_0$ from 1.12 to 1.31. It will be observed that the lowest end of the band was matched best (minimum VSWR) by the pair of seals having a dielectric constant of 1.31. The remainder of the band was matched best by the pair of end seals having an $\varepsilon'/\varepsilon_0$ of 1.22. For this feed, the pair having a constant of 1.12 gave the poorest performance. The final match (not illustrated) for this feed was obtained by using the 1.22 end seals and a single tuning iris properly positioned. The loss tangent of the dielectric materials was 0.0003.

The effect of the end seals on matching is perhaps more graphically shown in Fig. 4. The VSWR-frequency relationship for this feed was determined without and with the 1.22 end seals, in both cases without use of the tuning iris. The end seals provided greater uniformity at a VSWR generally well below 1.10.

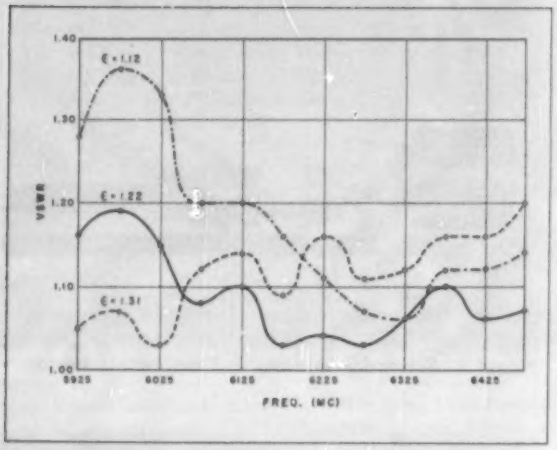

Figure 3. Voltage standing wave ratio vs. frequency for three end seals.

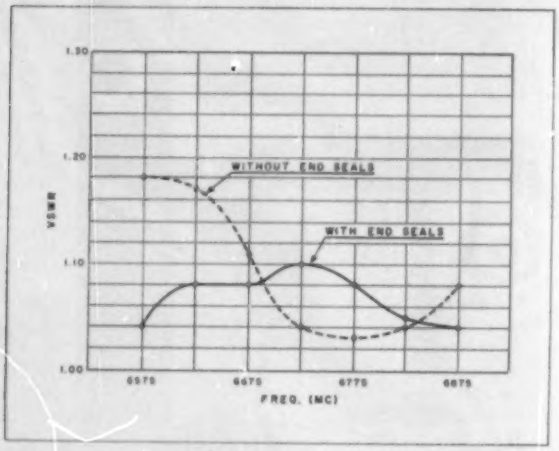

Figure 4. Voltage standing ratio vs. frequency with and without 1.22 ε end seals.

A New GCA Antenna

A volumetric scanning ground-controlled-approach antenna was designed by the Microwave Antennas and Components Branch of Naval Research Laboratory for Rome Air Development Center (Ref. 1). It permits coordinated control of multiple landings of high-speed aircraft because of its increased resolution and solid, three-dimensional rapid-scan coverage. Fig. 5 shows the scanner and lens mounted on the pattern test dolly at the USAF Antenna Proving Range.

There were three interesting mismatch problems which were solved by using special dielectric materials. First, the feed-circle mismatch was tuned out by use of quarter-wavelength-thickness dielectric "slugs" whose dielectric constant was selected to give VSWR equal to the mismatch to be tuned out. The "slug," for X-band waveguide, measures 0.400″ by 0.900″ by a quarter-wavelength in the dielectric; it may be cut readily with a saw or abrasive wheel from a sheet of material having throughout its volume the correct value of dielectric constant. A series of such sheets, varying in steps of about 0.05 unit of $\varepsilon'/\varepsilon_0$ at the operating frequency, provides a convenient, practical "tuner bank"

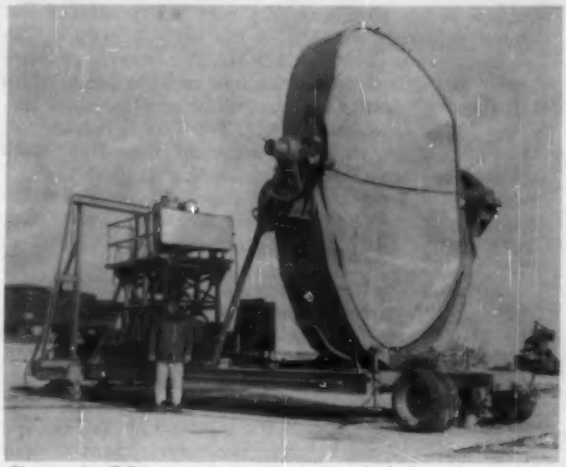

Figure 5. GCA antenna with tailored dielectric matching radome.

Figure 6. Low loss dielectric radome for helix antenna.

with which a fairly broadband match can be obtained without making any mechanical alteration of the component being matched.

Second, these dielectric "slugs" were used to match out the tapered section of the fabricated channels in each layer of the organ-pipe.

The third mismatch to be corrected was that of the organ-pipe aperture to free space. It was tuned out by means of a three-quarter-wavelength-thick sheet of dielectric positioned in front of the organ-pipe aperture, the dielectric constant being precisely equal to the VSWR desired. This dielectric sheet, which measures 6′ by 3′ by 0.87″ thick, also serves as the radome cover for the organ-pipe aperture; consequently, it is called a matching radome. The optimum position of this radome was found to be about 0.5″ away from the organ-pipe aperture.

The dielectric constant of the material of the matching radome was 1.26 ± 0.02 and its loss tangent was below 0.0005, both a X-band. The desired thickness of 0.87″ was obtained by machining the molded material. The series of 12″ by 12″ by 1″ sheets from which the dielectric "slugs" were cut as needed were required to have equally low loss tangents and the following values of $\varepsilon'/\varepsilon_0$: 1.16, 1.20, 1.23, 1.26, and 1.30.

This GCA antenna was placed in test service at Griffiss Air Force Base in the summer of 1957. A report (Ref. 6) received on June 19, 1958 stated that the matching radome had then been exposed to the weather substantially for four seasons, that it showed no visible deterioration, that it had performed satisfactorily whenever the equipment was used. The radome is the large, rectangular white object to the left-center of Fig. 5.

An Airborne Radome

A Gabriel antenna—an airborne flush-mount transmitter-receiver (Fig. 6)—embodies a 1¼ turn helix

recessed in an aluminum die cast cavity with a flat radome to which one end of the helix is bolted. The frequency range is 950 to 1525 Mc. The beam is perpendicular to the face of the antenna and the beam-width at half-power points is equal to or greater than 50°, except for 10% where it is 45°. The VSWR is less than 1.5 to 1.0 when measured on a ground plane 1/16" thick and 2' in diameter. Polarization is circular, with the circularity ratio equal to or less than 4 db for the entire frequency range. The power/voltage rating is 400 watts. Operating ambient temperature limits are —65°C to +85°C.

The radome is approximately 9.5" in diameter by 3/16" thick; 2,950 were molded early in 1958 in CYMAC 325, a Delaware Research dielectric compound manufactured and sold by American Cyanamid Company. This radome constitutes an important part of the construction: mechanically, electrically, economically. Precise location of the bolt-holes is essential; the radome is used to hold the helix in the correct position. The electrical properties must be maintained upon long-continued exposure to the elements and to flight. This dielectric material is molded readily by low-cost, high-speed techniques; the radome cost was realistic.

This antenna with the radome in place passed handsomely severe shock and vibration tests.

Microwave Components

Co-axial cable spacers, directional couplers, trimmers for oscilloscopes, high voltage blocking capacitors, polarizers to discriminate against rain clutter, phase shifters, transmission delay lines: the microwave components demanding special dielectric materials of the highest quality, readily formed into useful shapes with maintenance of the needed properties, seem endless in type and number. Dielectric constant often must be held to a precise value and be independent of frequency; low loss is essential as well. The material must mold to close dimensions and must hold the dimensions, often under continued pressure. Maintenance of quality must begin all the way back at the monomers out of which the composition is made and be the cardinal point at every step to the finished component. In microwave work, it is not sufficient that the molding compound—the dielectric material—be formulated to have the particular combination of electrical and mechanical properties required for optimum performance of the microwave equipment. These qualities must be present as well in the molded or extruded part. The fabricator quite literally can make or can break the value of the chemist's formulation.

Perhaps nowhere does quality have greater importance than in Navy submarines. An end seal insulator in an antenna outboard of the hull that "cold flows" can mean sea-water within the submarine. An end seal insulator that suffers a loss in surface insulation resistance, that degrades in flashover voltage rating when wet and dirty, as it inevitably is for days on end, that is not capable promptly of high electrical performance when the antenna is raised above the surface of the sea, can mean failure of a mission.

More than 1000 silicone alloy end seal insulators have been made on several orders since 1956 for this service, replacing the fluorocarbon insulator used previously. This insulator is shown in Fig. 7; the part to the left is the splash shield. It also is shown mounted on a submarine in Fig. 8. After continuous exposure to the elements for one year, the aged physical properties showed little change (Fig. 9) and the aged electrical properties compare favorably with their initial values

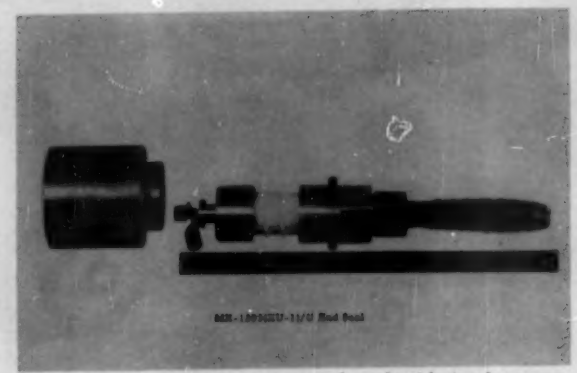

Figure 7. Submarine antenna end seal with insulator.

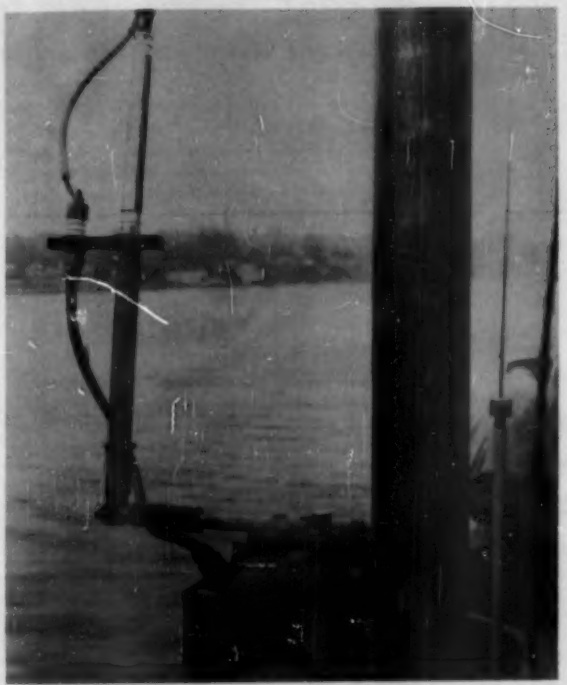

Figure 8. Antenna end seal mounted on submarine.

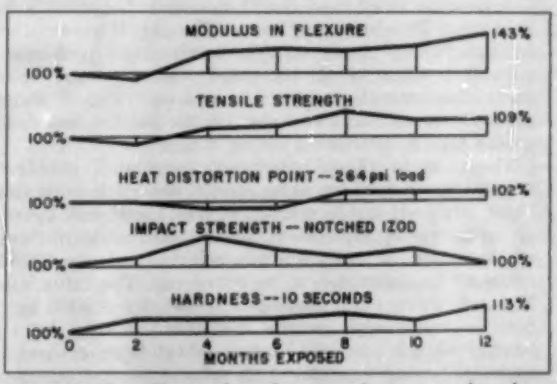

Figure 9. The effects of outdoor weathering on the physical properties of a silicone alloy shown as percentage of initial values.

(Fig. 10). More striking perhaps is the very rapid recovery of the silicone alloy insulator versus the fluorocarbon when raised out of the sea-water (Fig. 11).

Not only is performance in service better, the newer insulator costs the Navy only about 30% of the price of the fluorocarbon insulator.

In a land-based application involving exposure in mountainous localities to cloud and fog, rain and snow, some 5,600 silicone alloy antenna spreader insulators have been made on repeat orders, in preference to the ceramic insulator formerly used.

Conclusion

Compared with other materials used as dielectrics and insulators, the score to date for these special compositions whose properties have been "tailored" by the chemist is:

(a) Versus ceramics, these new dielectrics have been found to maintain better their electrical surface insulation resistance under adverse weather conditions, to be more resistant to icing-up, in certain formulations to be much tougher, to be more readily fabricated into finished components of lighter weight, to be machineable without loss of their surface electrical properties.

(b) Versus polymethyl methacrylate, Cymac 325 exhibited superior heat resistance, excellent dimensional stability, superior moldability, better dielectric characteristics.

(c) Versus a polyamide, these compositions have radically lower water absorption, with the finished part remaining truer to design dimensions, have better dielectric characteristics which are maintained in the presence of high humidity.

(d) Versus polystyrene, microwave components made of the low electrical loss silicone alloy maintain their dielectric and electrical properties where exposed to handling, to the weather and to the contamination often experienced in service. For example, it is superior in RF flashover voltage at 100% humidity. It withstood continuous outdoor exposure for more than a year without crazing or cracking. It machines readily and well.

(e) Versus polytetrafluoroethylene, these alloys have superior resistance to deformation under load at normal and elevated temperatures. They are more conveniently, more readily and much more cheaply fabricated into component parts. They can be bonded to themselves and to metals. Most of them provide a saving in cost per pound of molding compound and all of them provide a saving of some 50% in weight, as well as greater strength.

We no longer have to rely on "off-the-shelf" properties, on a slab of hardened pitch. The ability and willingness of the chemist to formulate dielectric and insulating materials to meet specific property needs of the microwave engineer has resulted in the use of these superior compounds for antenna insulators — post, spreader, stand-off, strain, end seal—and for antenna radomes, for co-axial cable spacers, rotary joint probes, waveguide components, directional couplers, trimmers for oscilloscopes, high voltage blocking capacitors, lens antennas of various types, dielectric radiators, end seals for pressurized antenna feeds, wave polarizers of several designs and characteristics, weather-proofing matching radomes for large radars. The usefulness of these uncommon but readily formulated and molded materials is limited only by the concern of the microwave engineer for better equipment, by the expertness of the quality-conscious molder and extruder, by the ingenuity of the chemist able and willing to serve the important and growing microwave industry.

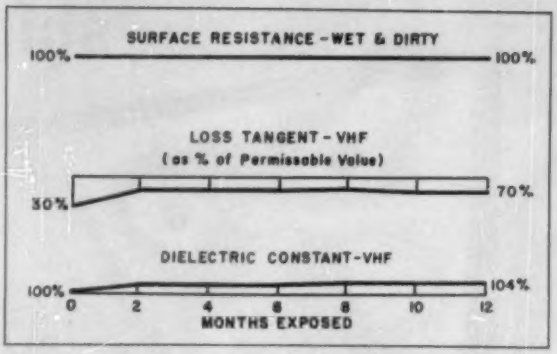

Figure 10. The effects of outdoor weathering on the electrical properties of a silicone alloy shown as percentage of initial values.

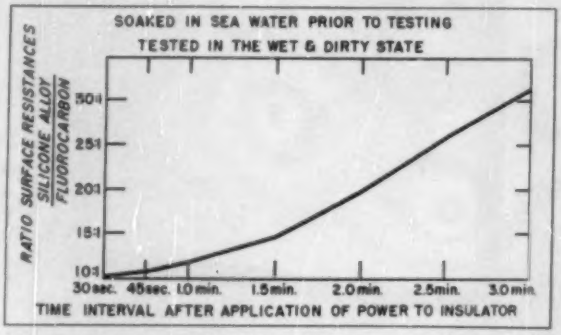

Figure 11. The comparative recovery of a silicone alloy vs. flurocarbon samples exposed during a 37-week submarine cruise and soaked in sea water prior to testing. The values represent the ratio of surface resistances in megohms/square at 1 mc.

Acknowledgement

The author welcomes this opportunity of acknowledging publicly his debt to associates in his company and to: Kenneth L. Blaisdell, Cletus M. Dunn and Robert W. Turner of the U.S. Navy Underwater Sound Laboratory; Dr. John I. Bohnert, H. Paris Coleman, William S. Gabriel and Dr. Arthur E. Marston of the U.S. Naval Research Laboratory; Moses A. Diab of Rome Air Development Center; and Steven Galagan, Director of Engineering of the Electronics Division of the Gabriel Company.

References

1. Gabriel, W. F., Peeler, G.D.M., Coleman, H. P., and Archer, D. H. *Volumetric Scanning GCA Antenna Design.* U.S. Naval Research Laboratory Report 5019. November 15, 1957.
2. Jeans, James. *Electricity and Magnetism.* Cambridge University Press.
3. Lodge, Sir Oliver. *Philosophical Magazine.* Vol. 28, p. 48. 1889.
4. Loehwing, D. A. *On the Beam.* Barron's. June 30, 1958. p. 3.
5. Luneberg, R. K. *The Mathematical Theory of Optics.* Brown University Press.
6. Oral Communication.

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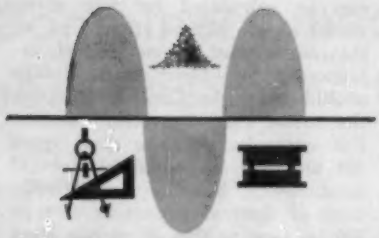

Edited by Louis Paggi, *Consultant*
E. I. du Pont de Nemours & Co., Inc.

MOLDING CYCLES

Suggestions in Mold Temperature Control

L. Paggi

The importance of controlling the temperature of a mold has often been emphasized. Although recognized that this molding variable should be controlled, it is not always possible to do so by conventional methods. Thus, special factors, such as the thermal conductivity of the metals used in the mold, may be well worth considering as a means to solving certain problems in temperature control.

Some problems which may arise are:

1. Unbalanced thermal conductivity
2. Highly stressed moldings
3. Defective surface and voids
4. Excessive cycle time
5. Inability to fill cavities
6. Ejection difficulties
7. Corrosion of cooling channels

Use of the following suggestions may be helpful to the molder in solving such problems. However, it should be recognized that we have not had an opportunity to test the effectiveness of the proposed techniques. The suggestions are based primarily on known and published properties of materials. Therefore, it is recommended that the molder test those that appear suitable for solving his particular problems before constructing production molds.

Balancing Thermal Conductivity

Certain molds cannot be adequately cored or are too expensive to core. This problem arises when knockout pins or sleeves must be so positioned that they interfere with the proper location of the cooling channels. It may also arise because of the geometry of the cavity or when a cavity is made up of more than one component part.

Taking advantage of the heat conductivity of different metals may often make it possible to overcome this problem.

If we examine the relative heat conductivity of the metals which may be used in mold construction, we will observe a considerable difference between certain metals. For example, carbon steel SAE1020 will conduct approximately 4 times as much heat in a given time as will stainless steel type 304. The same steel and nickel are approximately equal in this property. The thermal conductivity of beryllium copper is approximately 50% more than that of SAE1020 steel. Pure copper will conduct approximately 25 times as much as stainless steel type 304.

The quantity of heat carried through the metal is inversely proportional to its thickness. Therefore, the rate of heat transfer through copper will be equal to that through carbon steel when the distance across which the heat must travel, through a unit temperature difference, is six times as far in copper as in steel. This means that a copper lining or copper cores can be used to conduct heat away from a section of the mold which is at a remote location from the cooling channel at approximately the same rate as from an all steel cavity located near the cooling channel. The same basic principle can be used to maintain a more uniform temperature across the entire mold. A thin copper plate assembled between the cavity plate and support plate will tend to equalize the heat transfer between all of the cavities and cooling channels. This approach will be of greater value when the cooling channels are few in number and are spaced a considerable distance apart. Copper for this application should be cold rolled or cold drawn to improve yield resistance.

Locked-In Stresses

The magnitude of stresses occurring in molded parts is a function of the rate of cooling. Stresses of a higher order can be expected when molten polymer is cooled rapidly. Local stresses are a function of uneven cooling. If metal chosen for the cavity has a high thermal conductivity, the problem with stresses will be aggravated. The magnitude of stresses may be reduced by constructing the cavity from a metal having low heat conductivity. Uneven cooling may be minimized by lining the external wall of the same cavity with a metal having a high heat conductivity. A typical example of such a cavity is one made of nickel or nickel alloy over which is electrodeposited a shell of copper. In construction of this type, the thickness of the metal forming the low conductivity wall must be relatively uniform. The thickness of the high conductivity wall is not as critical.

Poor Surface, Sinks and Voids

Practically all surface imperfections, as well as voids, are due in part to rapid cooling. The condition may therefore be alleviated by using cavities of a metal having low thermal conductivity.

Long Cycles

When not detrimental to properties, cycles may be reduced by use of a metal having high thermal conductivity for the cavities.

Inability to Fill Thin Sections or Large Areas

The ability to penetrate between narrowly spaced cavity walls is controlled by several factors among which is rate of heat loss from the surface. Occasionally we encounter cavities for relatively thin and large-area parts which are difficult to fill unless extremely high temperatures and pressures are used. These molding conditions usually result in low yields or poor quality. Here again the use of low thermal

conductivity metal for cavities should render assistance.

Poor Release of Part from the Cavity

Difficulties with ejection are often the result of surface structure of the solidified polymer as well as insufficiently cooled parts. Semi-crystalline polymers will generally develop a harder surface and therefore eject with greater ease when cooled, indicating a preference for low heat conductivity metal cavities. Where faster cooling can be tolerated, it can be achieved with cavities of high heat conductivity metal.

The difference in thermal conductivity of different metals may also be utilized to delay or speed up the hardening of the plastic at local points in the mold, as for example gates, runners and sprues.

Corrosion of Cooling Channels

Corrosion of the cooling channels in steel molds can of course be prevented by using oil as a circulating coolant. The low specific heat of oil, however, makes it a very inefficient coolant. Dissolving a small quantity of soluble oil in the water used in the mold circulator will prevent corrosion without seriously effecting cooling efficiency.

Thermal Isolation

Molds designed for runnerless molding often present a thermal isolation problem. Insulation by means of compressible materials such as asbestos board can result in damage to molds in the event of local yielding. This problem may be alleviated by the use of stainless steel for such components as grid plates, primary and secondary sprue bushings and hot nozzles.

Thermal Expansion

The use of dissimilar metals in mold construction can introduce problems with binding or warping of mold components. It can also result in cracking of cavities, especially when dissimilar metals are welded together. Since the total change in dimension is directly proportional to the size of the part, the larger the part the greater the problem with thermal expansion or contraction.

The amount of thermal expansion resulting over the temperature range in which the mold will be operated can be calculated for any given metal used. Where tight fits or clearances must be maintained, allowances for dimensional change should be made. Care in choosing the metal can also yield benefits. For example, stainless steel types 304 and 330 are equal in thermal conductivity, but the mean coefficient of thermal expansion of type 330 is close to that of carbon steel (SAE1020) whereas type 304 has a larger coefficient of thermal expansion and, in fact, is very close to that of copper.

★ ★ ★

Next Month . . .

Beginning with the January issue, Molding Cycles will be a question-and-answer forum conducted by Mr. Paggi. If you have a question on molding, send it to Louis Paggi, Sales Service Laboratory, Polychemicals Dept., E. I. du Pont de Nemours and Co., Inc., Wilmington 98, Delaware. Your question will be reviewed by Mr. Paggi and other eminent authorities, and the answer will be printed in the *Journal*.

Processing of Thermoplastic Materials

Volume II of the SPE Plastics Engineering Series, *Processing of Thermoplastic Materials*, will be published January 5, 1959, by Reinhold Publishing Corp. It is both a basic textbook and a reference for engineers.

The volume is divided into three major sections: Fundamentals, Applications and Plastics Properties. The Fundamentals section describes basic theories of flow behavior, heat transfer and mixing on which the design of plastics processing equipment is founded. The Applications section is broken down into categories of equipment. It demonstrates the derivation of equations which describe the behavior of plastic materials in a given piece of processing equipment. Typical applications of the design equations are illustrated. The Plastics Properties section is a compilation of basic data which are needed to apply the equations.

Technical Editor of the book is E. C. Bernhardt, Dr.-Ing., E. I. du Pont de Nemours and Co. Inc. Administrator is J. W. Lindau, III, M.M.E., Southern Plastics, Inc. A list of the chapters and authors follows:

Section I—Fundamentals

Flow Behavior—A. B. Metzner, Sc.D., University of Delaware

Heat Transfer and Thermodynamics—J. M. McKelvey, Ph.D., Washington University, St. Louis

Mixing and Dispersing—W. D. Mohr, M.S., Massachusetts Institute of Technology

Section II—Applications

Extrusion—J. B. Paton, B.S.; P. H. Squires, Ph.D.; W. H. Darnell, Ph.D.; and F. M. Cash, B.S.; all of E. I. du Pont de Nemours Co., Inc.; and J. F. Carley, Ph.D., *Modern Plastics*, Breskin Publications, Inc.

Injection Molding—G. B. Thayer, B.S.; J. W. Mighton, B.S.; R. B. Dahl, B.S.; and C. E. Beyer, B.S.; all of Dow Chemical Co.

Calendering—D. I. Marshall, Ph.D., Union Carbide Plastics Co.

Mixing and Dispersing Processes—J. T. Bergen, M.S., Armstrong Cork Co.

Sheet Forming—N. Platzer, Ph.D., Monsanto Chemical Co.

Forming of Hollow Articles—G. P. Kovach, Dipl.-Ing., Foster-Grant Co.

Sealing and Welding—B. P. Rouse, Jr., Ph.D., and T. M. Hearst, B.S., both of Tennessee Eastman Co.

Section III—Processing Properties

Processing Properties—R. F. Westover, M.S.E., Bell Telephone Laboratories

Processing of Thermoplastic Materials is 752 pages. Price to SPE members and SPI individual members is $14.40. Price to non-members is $18.00. Advance orders will be accepted at the SPE National Office, 65 Prospect St., Stamford, Conn.

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Edited by R. D. Sackett
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SPEAKING of EXTRUSION

High Density Polyethylene Film in Packaging

Robert Doyle
Phillips Chemical Company
Sales Service Laboratory

High density or linear polyethylene films may be classified into two distinct types based upon the cooling techniques used in their production. The first type includes those films which are cooled relatively slowly to give a naturally translucent appearance. This type offers the maximum in stiffness, impermeability and resistance to grease. The second type includes films produced by various quenching and drawing techniques employed to develop transparency and sparkle. The latter properties are obtained to a remarkable degree with only a relatively small change in the density-dependent properties such as stiffness and impermeability. In all cases, the higher temperature resistance of the original linear polyethylene resin is retained.

Recent articles (Ref. 1, 2 and 3) have separately described the extrusion and properties of these various types of film produced from Phillips-type 0.96 density polyethylene. The object of this paper is to summarize the various types of film that have been produced thus far, to compare their packaging properties and uses, and to present a further progress report on the results that are being achieved with heat sealing these new films on commercial equipment.

This paper was presented at the Regional Technical Conference of the Western New England Section, SPE.

Slow-Cooled Film

The best example of a slowly-cooled high density polyethylene film is that produced by the conventional blown tubing process (Fig. 1). Conventional extrusion techniques and equipment may be employed to produce this film, provided only that particular attention is given to the following:

1. Begin with a clean die and avoid "burning" the die in starting up.
2. Level and align all equipment accurately.
3. Hold good gauge control, using proper die adjustment and circumferential uniform air from the air ring.
4. Use low stock temperatures—only 315° to 360°F in some cases.
5. Keep "frost line" of bubbles as low as practicable.
6. Shield bubble from any and all drafts.
7. Flatten the bubble with perforated plates rather than rollers, using a small included angle between the plates.
8. Use centerwind type of wind-up equipment rather than surface wind because of the stiffness and low coefficient of friction on the film.

Film produced by the above process will be translucent in appearance but will offer the maximum in stiffness, impermeability and resistance to grease if compared with any other type of polyethylene film which is presently available. Light gage film thus produced is finding applications ranging from the packaging of potato chips, where grease resistance and low MVTR are im-

(*Continued on page 46*)

Figure 1. Extrusion of high density polyethylene blown tubing.

Figure 2. Low cost trays from high (0.96) density polyethylene blown tubing.

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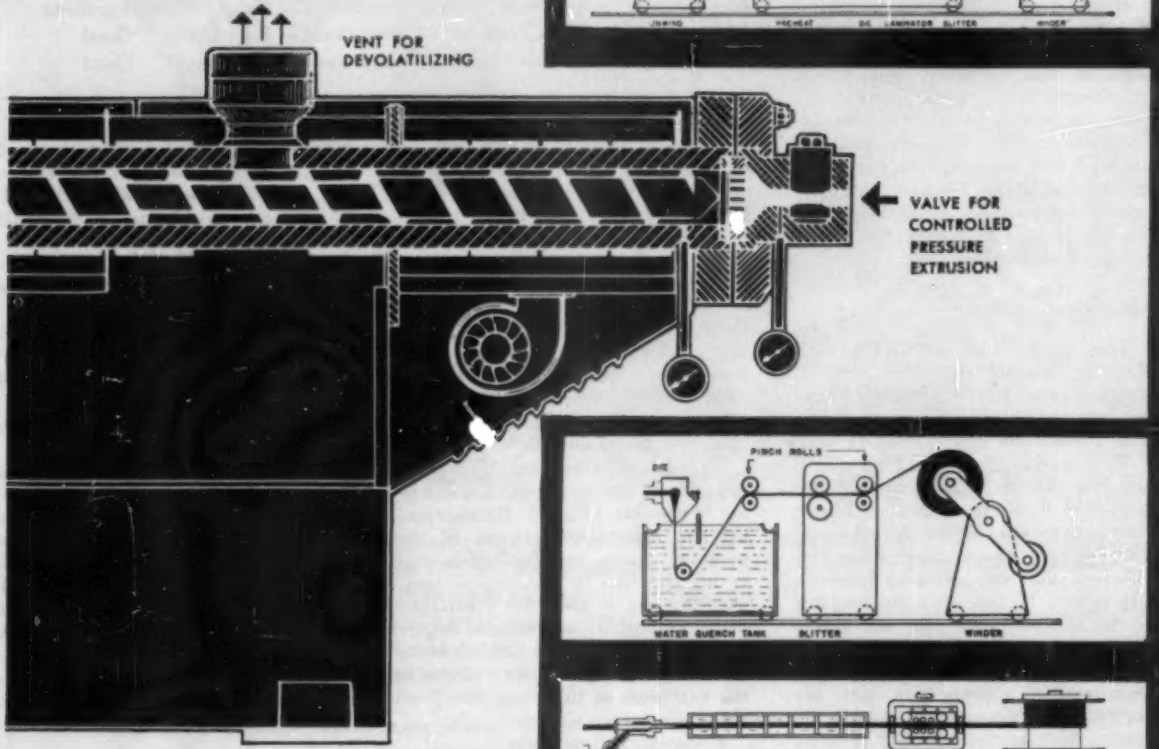

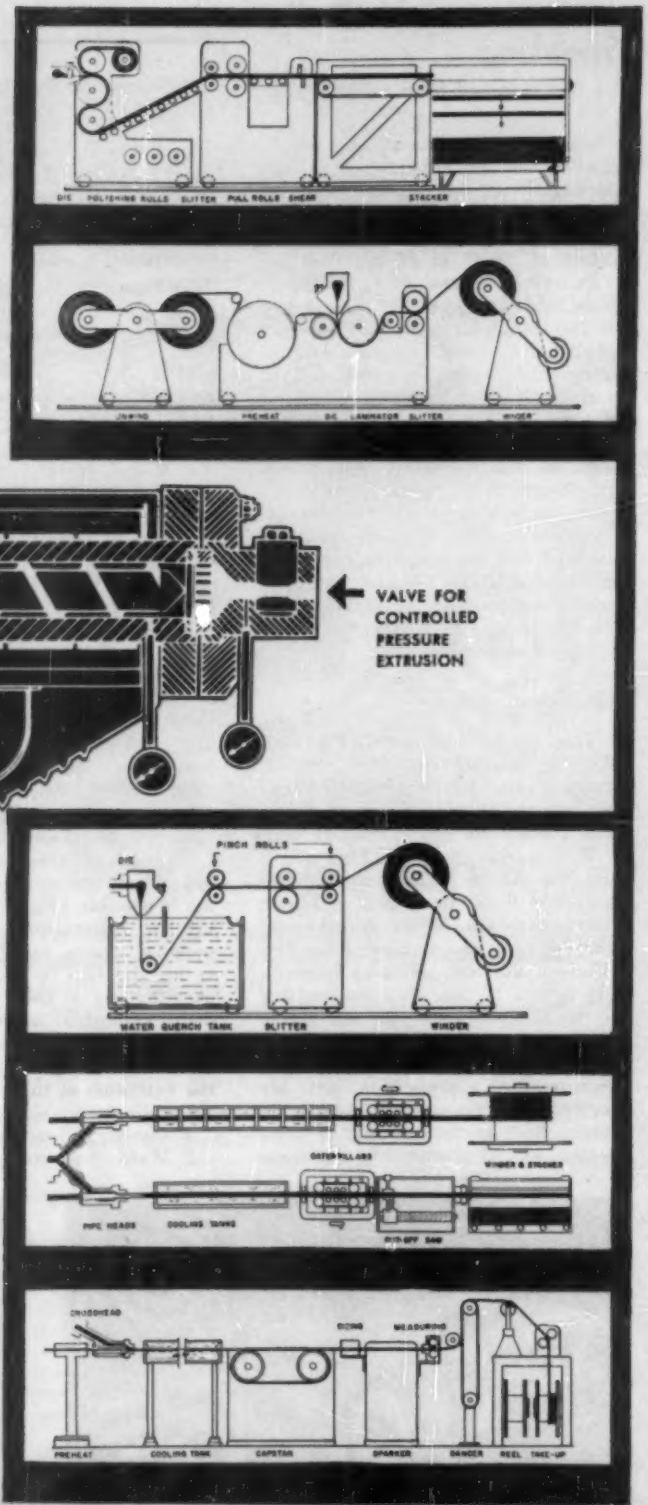

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Speaking . . .

(*Continued from page 44*)

portant and the reduced light transmission is an advantage, to the packaging of sterilizable hospital supplies and instruments which must be steam sterilized in a sealed pouch at 250°F for 20 minutes.

In heavier gages, (4 to 20 mils), blow tubing (Fig. 2) has the rigidity to be thermoformed into low-cost small containers of exceptional durability which may be covered with a clear film and heat sealed around the top lip (Fig. 3) to protect foods, tools and a variety of other products. In this range of applications, calendered high density polyethylene film, which is also translucent, potentially offers the advantage of even greater economies in high volume applications plus permitting greater control of orientation for thermoforming and also the possibility of embossing.

Quenched Film

The subject of quenched high density polyethylene film may be divided into two sub-classes. These are immersion or wet quenched film and surface or dry quenched film.

With surface quenched film, where the film is either slot extruded onto a chilled drum or drawn as blown tubing over some other chilled metal surface, only one surface of the film receives the full, effective quenching action. Hence, only one surface of the film will be bright and glossy while the other surface will tend to be somewhat duller and so the net "see-through" properties are affected. Double drum quenching, where both surfaces would be contacted, would presumably eliminate this non-uniformity, but as yet we know of no operations employing double drum quenching for high density polyethylene film.

Meanwhile, single drum or surface quenching provides excellent directional uniformity and an intermediate degree of transparency and sparkle. Also, the initially low output rates reported for single drum operations appear to be capable of considerable improvement through developments in die design and operating techniques.

In immersion or wet quenching operations, the optimum in quenching is possible (Fig. 4). By supressing the spherulitic growth of the polymer chains and by highly orienting the film in the critical temperature region near the crystalline melting point, an exceptional degree of transparency and sparkle can be achieved. Briefly, the key points in the extrusion of this clear film from a slot die are:

1. Use high flow resin.
2. Water bath temperature must be under close control, with good circulation, in 140° to 150°F range.
3. Film must be quickly quenched; die should be only about ¼" from water.
4. Clarity improves with orientation; use 20:1 to 40:1 draw-down from die.
5. Moderate stock temperatures are best, generally between 425° and 510°F, depending on speed and thickness.
6. Fine screen packs promote uniformity.

Guided by the above suggestions, light gage clear film has been produced from high density polyethylene at speeds of almost 200 fpm without water carry-over and much higher speeds appear to be practical. The resultant film has exceptional strength in the machine direction, has the advantage of a built-in-tear-tape feature, and generally appears to offer significant economies over M, MS and MSA grades of cello-

(*Continued on page 48*)

TABLE I

Films from Phillips-Type Polyethylenes

Process	Blown Tubing	Surface Quenched	Immersion Quenched	Immersion Quenched
Resin	Type 9	Type 50	Type 50	X-18
Orientation	Variable	Low	High	High
Tear Tape	No	No	Yes	Yes
Stiffness	Excellent	Very Good	Very Good	Good
Slip	Excellent	Good	Good	Good
Clarity	Translucent	Fair	Good	Excellent
Sparkle	None	One Side	Good	Excellent
Impermeability	Excellent	Very Good	Very Good	Good
Greaseproofness	Excellent	Very Good	Very Good	Good

Figure 3. Thermoformed frozen food trays ready for sealing.

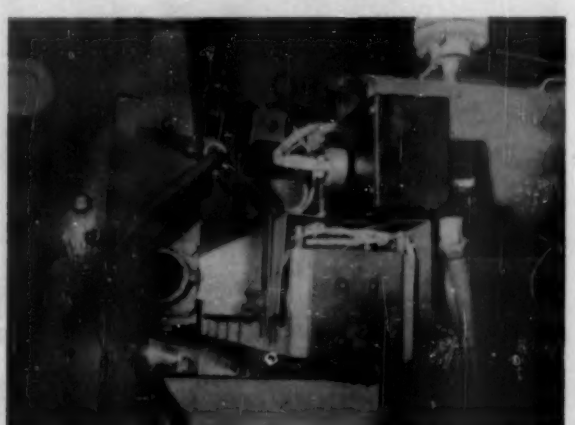

Figure 4. T-die is located close to water bath for quick quenching of high density polyethylene film.

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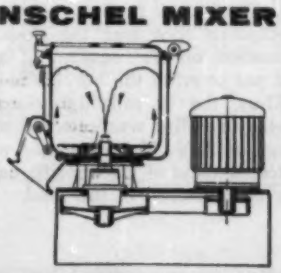

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Speaking . . .

(*Continued from page 46*)

phane for many overwrap applications. At thicknesses above roughly 1½ mils (0.0015"), the transparency drops off significantly and the tear-tape feature becomes obscured.

Still clearer and more sparkling films may be obtained via the immersion quenching technique if one starts with one of the newer resins being produced by the Phillips polyolefine process. These new polymers will yield the clearer but softer films which are frequently desired for breadwraps and for packaging textiles and similar products. A comparison between the various types of film which have been described are presented in Table I. This table is designed to point out the principle differences which arise as a result of film processing techniques. Not listed are the properties common to all of the films described. These common properties which may be important in a packaging film are: nontoxic and inert nature; heat sealable; tough at low temperatures; non-blocking; essentially unlimited shelf life; printable after treatment; steam sterilizable at 250°F.

Specific data for some typical film samples are given in Table II. The permeability data in this table reveal why high density polyethylene films can provide substantial savings in film costs. This is because they can give the equivalent barrier protection with as little as one-half the thickness of films now in use. In Table III is a tabulation of films considered for a typical overwrap application and some of the costs involved, including a span of possible prices for high density polyethylene film. Actually, in a particular application the 1 mil conventional polyethylene film was too limp to be handled on the equipment and it did not provide the barrier needed. Thus, the ¾ mil high density polyethylene film was selected at a savings of 33%. This example well illustrates some of the specific cases being encountered in the field.

Heat Sealing

In the overwrap field, the newer machines designed for conventional polyethylene film are well able to handle high density film also. However, there have only been a limited number of these machines available to date.

TABLE II

Typical Properties of Films from Phillips-Type Polyethylenes

Film Process	Blown Tubing	Drum Cast	Water Bath Quenched	
Resin	Type 9	Type 50	Type 50	X-18
Thickness-mils	1.0	0.6	0.7	0.7
Tensile-psi				
MD	3800	3300	9000	8000
TD	3000	3300	4000	3000
Elongation-%				
MD	175	200	200	200
TD	200	20	25	25
Elmendorf-g/mil				
MD	30	5	20	20
TD	200	40	Does not tear	
Coefficient of Friction	0.27	Air side-0.3 Cast side-high	0.4	0.35
MVT-g/mil/100 in.²/24 hr	0.32	0.42	0.44	0.58
Gas Permeability x 10^9 cc. cm/sec/cm². cm Hg				
O_2	0.07	0.12	0.13	0.16
CO_2	0.21	0.42	0.48	0.72
% Haze	85	15	6	3

TABLE III

Comparison of Film Costs for Equivalent Machine Handling and Barrier Properties

Film	Resin Cost/lb	Thickness	Film Cost/lb	Cost/1000 sq in.
Marlex	43¢	¾ mil	74¢*	1.89¢
	43¢	¾ mil	72¢*	1.85¢
	43¢	¾ mil	68¢*	1.74¢
Conventional Polyethylene	35¢	1¼ mil	53¢	2.20¢
	35¢	1½ mil	53¢	2.64¢
Cellophane (M & MS grades)	—	300 gage	62¢	3.0¢

*Span of some quoted prices, dependent on quantity, etc.

Because of its high stiffness, low elongation and high tensile, high density polyethylene film has naturally been considered for use on "cello" machines and it has repeatedly been demonstrated that this is entirely practical as far as transporting the film is concerned. Nevertheless, the sealing section must be changed to a type suited for a thermoplastic film.

Since cellophane is not sealable or thermoplastic in itself, but is coated over with a thin, heat-sealing layer, it can withstand being brushed across a fixed hot plate to seal the coated faces together. With polyethylene, the package must be conveyed past and protected from direct contact with the hot metal or other heat source through the use of belts or rollers coated with Teflon or silicone rubber.

Where machines have been converted for use with the lower density types of polyethylene film, long cool-

TABLE IV

Processes for High (0.96) Density Polyethylene Film

Type of Process	Specific Process Examples	Outstanding Film Properties	Packaging Applications
I. Slow cooled	1. Blown tubing-air cooled 2. Calendering	Minimum permeability Maximum Stiffness	Sterilizable packages, snack foods, unit servings, thermoformed containers
II. Quenched A. Surface	1. Drum cast from slot extrusion 2. Blown tubing over cooling dan	Controlled orientation Uniform directional properties with intermediate clarity	Bags or overwraps requiring greater impact resistance
B. Immersion	1. Slot extruded through water bath	Maximum clarity with tear tape feature	Overwraps for cigarettes, candy, meats, cereals, bakery goods, soft goods medical supplies, paper products for home use

ing sections have also been required. With high density polyethylene film, this need is generally eliminated and so the conversion parts are simpler, smaller and less costly. At least one progressive packaging machinery manufacturer is already offering conversion kits for his own machines and other manufacturers are expected to follow this lead.

On still other machines in the overwrap field, it has been found that the sealing time, designed for cellophane, was excessive for high density polyethylene film. By installing a variable speed drive over a higher speed range, the dwell time could be adjusted down to give good seals. Due to the high degree of orientation in the film, flying, serrated cut-off knives—as found on certain machines—are unable to cope with clear high density polyethylene film. Either a hot wire cut-off or scissor-action knives can be substituted with excellent results.

On bag packaging types of equipment, fusion seals (made by a hot wire or side weld cut-off style of bar) appear to offer a slight advantage over conventional bar seals and impulse seals, where suitable. This evaluation is based upon relative seal strengths plus the neatness and appearance of the seals produced. However, by installing proportioning-type temperature control instruments on bar sealers, the quality of the seals produced may be improved. Still further improvements are expected to result from the intensive study of heat sealing factors which is now underway.

Summary

As tabulated in Table IV, the principal types of film which have already been made from high density polyethylene have been reviewed in terms of processes, properties and applications. A classification of these film types has been suggested to aid in the selection of the best for specific applications. Additional types may be expected, due not only to process developments, but also to polymer developments. An example is given of a film extruded from one of these newest olefin polymers.

In addition, some of the latest findings which have resulted from cooperative programs with package machinery builders and users have been summarized to indicate the rapid strides that are being made in developing the best techniques and equipment for these new films.

Bibliography

(1) Doyle, R. "Extrusion and Forming of High Density Polyethylene Blowing Tubing," *Modern Plastics*, p. 137 (May 1958).

(2) Doyle R. and Martinovich, R. J., "A Polyethylene Overwrap Film," *Modern Packaging*, p. 215 (May 1958).

(3) Doyle, R., "Extrusion of Clear Film from High Density Polyethylene," SPE Journal, p. 35 (June 1958).

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ERRATA . . .

Speaking of Extrusion in the November *SPE Journal*, "Drives for Extruders" by Gordon D. Campbell, Jr., contained some incorrect information. On page 58, paragraph 2 under "Test Results" appeared as follows:

"For a single purpose extruder, which is required to process only one raw material, a constant torque drive, if carefully chosen for speed range, will do the job satisfactorily. For a multi-purpose extruder, which is required to process several raw materials, the constant horsepower drive is more desirable, since it will handle the most difficult jobs requiring lower torques at higher screw speeds (conventional polyethylene)."

Correctly stated, the last sentence should read:

". . . since it will handle difficult jobs such as rigid PVC at slow screw speeds and high torques, while still providing the necessary speed range to handle the easier jobs which require higher screw speeds at lower torques (such as polyethylene)." ★ ★ ★

International Cooperation on Plastics Standards:

ISO/TC 61 RESULTS

SPE has a right to be proud of its co-sponsorship of the Eighth Annual Meeting of Technical Committee 61 on Plastics of the International Standards Organization in Washington last month. This meeting was solely for the purpose of working out standards for plastics products. The working groups were made up of 56 delegates representing the standards bodies of 12 countries—Czechoslovakia, France, Germany, Hungary, Italy, Netherlands, Poland, Sweden, Switzerland, United Kingdom, United States and USSR.

The U.S. delegation consisted of 16 men—9 of whom, incidentally, are SPE members. The official SPE representative at the meeting was Norman A. Skow.

The American Group of ISO/TC 61 formulates U.S. viewpoints on ISO matters and serves in advisory capacity to ASA, the U.S. member body of ISO. The American Group is under the leadership of ASTM Committee D-20 on Plastics. Representation is provided by SPE, SPI and MCA.

The American Group consisted of: Howard C. Adams, Monsanto Chemical Co.; William E. Brown, Dow Chemical Co.; Robert Burns, National Academy of Sciences: Charles L. Condit, SPI; A.A. Harban, Standard Oil Co.; Thomas Hazen, Union Carbide Plastics Co.; Gordon M. Kline, National Bureau of Standards: Frank W. Reinhart, National Bureau of Standards; Arnold H. Scott, National Bureau of Standards; Norman A. Skow, Synthane Corp.; Alfred C. Webber, Du Pont; Paul E. Willard, Food Machinery & Chemical Corp.; G.H. Williams, Bell Telephone Laboratories; R.R. Winans, N.Y. Naval Shipyard; Ralph Witt, Johns Hopkins University; E.Y. Wolford, Koppers Co.

One of the outstanding accomplishments of the conference was the completion of the monumental task of compiling a list of equivalent terms in French, English and Russian pertaining to plastics technology. The list, containing nearly 800 terms will be published as an ISO Recommendation.

Five new Draft ISO Recommendations were approved and will be submitted to the General Secretariat for distribution to the ISO member bodies. They are:

Standard Atmospheres for Conditioning and Testing Plastic Materials;

Melt Flow Index of Polyethylene and of Polyethylene Compounds;

Recommended Practice for Compression Molding Test Specimens of Thermoplastics Materials;

Recommended Practice for Compression Molding Test Specimens of Thermosetting Materials.

Recommended Practice for Injection Molding Test Specimens of Thermoplastic Materials.

Six Draft ISO Proposals were approved for formal letter ballot consideration of the Technical Committee. They are:

Tensile Properties of Plastics;

Testing of Plastics with the Torsion Pendulum;

Determination of the Viscosity Number of Polyamide Resins in Solutions;

Determination of Acetone Soluble Matter of Phenolic Molding Materials;

Method of Test for Tracking under Moist Conditions;

Vicat Softening Point.

Many other items were given further study and numerous items were added to the program of work. The eight groups of TC 61 held a total of 14 sessions and treated approximately 35 items.

The Committee adopted resolutions to have a document prepared on Methods of Measurement and Control of Relative Humidity in Large and Small Enclosures. Also, action was taken to organize a new working group to deal with specifications for the identification and quality control of plastics materials; and plans were made to consult with the ISO Committee on Rubber regarding standardization activity on cellular materials.

The next meeting of ISO/TC 61 will be held in Munich, Germany on October 26-31, 1959.

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Participants in the International Symposium on Plastics Testing and Standardization sponsored by ASTM for the American Group of ISO/TC 61. Front, left to right: A. Miklovicz, Hungary; F. W. Reinhart, USA; F. M. Jacobs, Netherlands; H. M. Glass, U.K. Back: R. Burns, USA; R. J. Painter, ASTM-USA; G. F. Hussey, Jr., ASA-USA; Gerhard Ehlers, Germany; W. Broberg, Sweden.

U.S.I. POLYETHYLENE NEWS

A service for processors and packaging executives by the makers of PETROTHENE polyethylene resins

Packaging Notes

Colorful striped polyethylene film makes possible unique package creations. Produced from U.S.I. PETROTHENE resins by a midwest extruder, the film is competitive with printed striped film in price. Unlike printed film, the film with extruded stripes looks equally attractive on both sides. The color will not rub or wear off.

Polyethylene film — with extruded-in stripes that won't rub or wear off — is equally attractive on either side and can be obtained in a raised or embossed effect to provide a rich feel.

The film is produced generally as a clear film with stripes of any single color. It is also possible to produce two different color stripes, or to construct a die to produce alternating stripes on a clear background, or even to obtain a three color effect. Translucency or transparency of the colors can be varied as desired. A raised or embossed effect is also possible. The film is made with standard extruders which have been modified considerably to make possible the fusing of two or three different color streams within the die.

The film is produced as tubing in production thicknesses ranging from 1.25 to 10 mils. It is expected to be used for novelty packaging of candy, cosmetics, stationery, some soft goods, toys, cotton balls and other drug items, and certain foods.

Transfer labeling of poly squeeze bottles is being done at savings of 75% in printing costs by means of a new direct thermal transfer method. The transfer labels are printed on a kraft paper carrier. Heat and pressure applied by a special machine transfers the legend to the squeeze bottle.

The method is said to combine the attractiveness and durability of preprinting with the versatility and economy of labeling. The transfer unit can be mounted on any standard wrapping, bundling or bagmaking machine.

New machine forms and heat-seals polyethylene-coated blanks to produce cartons and trays which are highly resistant to grease and moisture without the need for liners. The machine operates at speeds up to 180 or more units per minute. It is designed for packaging cookies, crackers, fig bars, confections, frozen foods, cosmetics, cigarettes, vegetables and other products.

Comprehensive Guide to Polyethylene Processing Completed by U.S.I.; Copies Now Available

100-Page Guide Covers Molding, Extrusion and other Problems

U.S.I. has just released a useful, comprehensive booklet on polyethylene processing. The 100-page booklet "PETROTHENE® Polyethylene . . . A Processing Guide"—is based to a large extent on research carried out by U.S.I.'s scientific staff and on experience gathered by its technical service engineers.

Abundantly illustrated, the booklet stresses practical shop information throughout, with only as much basic scientific theory as is needed to make the practical material readily understandable. The booklet discusses polyethylene properties, routine quality control tests and the various techniques for processing polyethylene—film and profile extrusion, extrusion-coating of paper and other substrates, wire and cable coating, injection molding, bottle blowing, thermoforming and others, along with related subjects such as heat sealing and film printing.

The booklet is filled with pages of invaluable shop advice for all types of processors. Many paragraphs are devoted to such specific problems as the causes and prevention of wrinkles in blown film, factors affecting the quality and economics of heat sealing, the machine conditions and resin properties which result in minimum "neck-in" and beading in paper coating and the effect of resin type and mold characteristics on cycle time or warpage.

"PETROTHENE® Polyethylene . . . A Processing Guide" is now available free to processors and convertors. For your copy, write to Editor, U.S.I. Polyethylene News, U. S. Industrial Chemicals Co., 99 Park Ave., New York 16, N. Y.

Poly-Coated Corrugated Board Now in Commercial Production

Poly-coated corrugated board is now available for the first time. The problem of high temperatures on the corrugator has been avoided by extrusion-coating the liner board at the mill level and using a cold adhesive for corrugating.

Photo courtesy Mead Board Sales Co.

Corrugating line on which polyethylene-coated corrugated board is now being produced.

Among the applications for corrugated poly-coated containers are:

Bulk shipment of meat, where moisture and grease-proof interiors reduce weight loss of the meat and eliminate loss of container strength through moisture pickup;

Shipment of furniture and other hard goods, where abrasion damage from the container has been a problem;

Bulk bakery and confectionary shipments, where absence of grease-wickage makes containers suitable for reuse or use as point-of-sale displays;

And in concrete construction forms, with the poly coating acting as a release agent.

Tests Show Many Aromatics Can Be Packaged In Poly

A two-year study has shown that a large class of essential oils can be packaged in polyethylene containers with little or no permeability loss.

The tests showed that oils of high viscosity and low terpene content experienced little or no weight loss.

In this group were such aromatics as Oil Bois de Rose; Oil Cassia Rectified; Oil Citronella Java; Oil Coconut Edible, N. F.; Oil Geranium Algerian; Oil Lignaloe Wood, Mexican; Oil Vertivert Bourbon; Oil Patchouly Penang; Oil Sesame U.S.P.; Oil Ylang Ylang; and Oil Almond Sweet expressed U.S.P.

From these, fragrance compounds have been developed for use in poly-packaged anti-perspirants, creams, lotions, and shampoos.

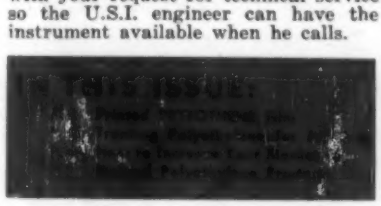
Cleveland OK's Plastic Pipe

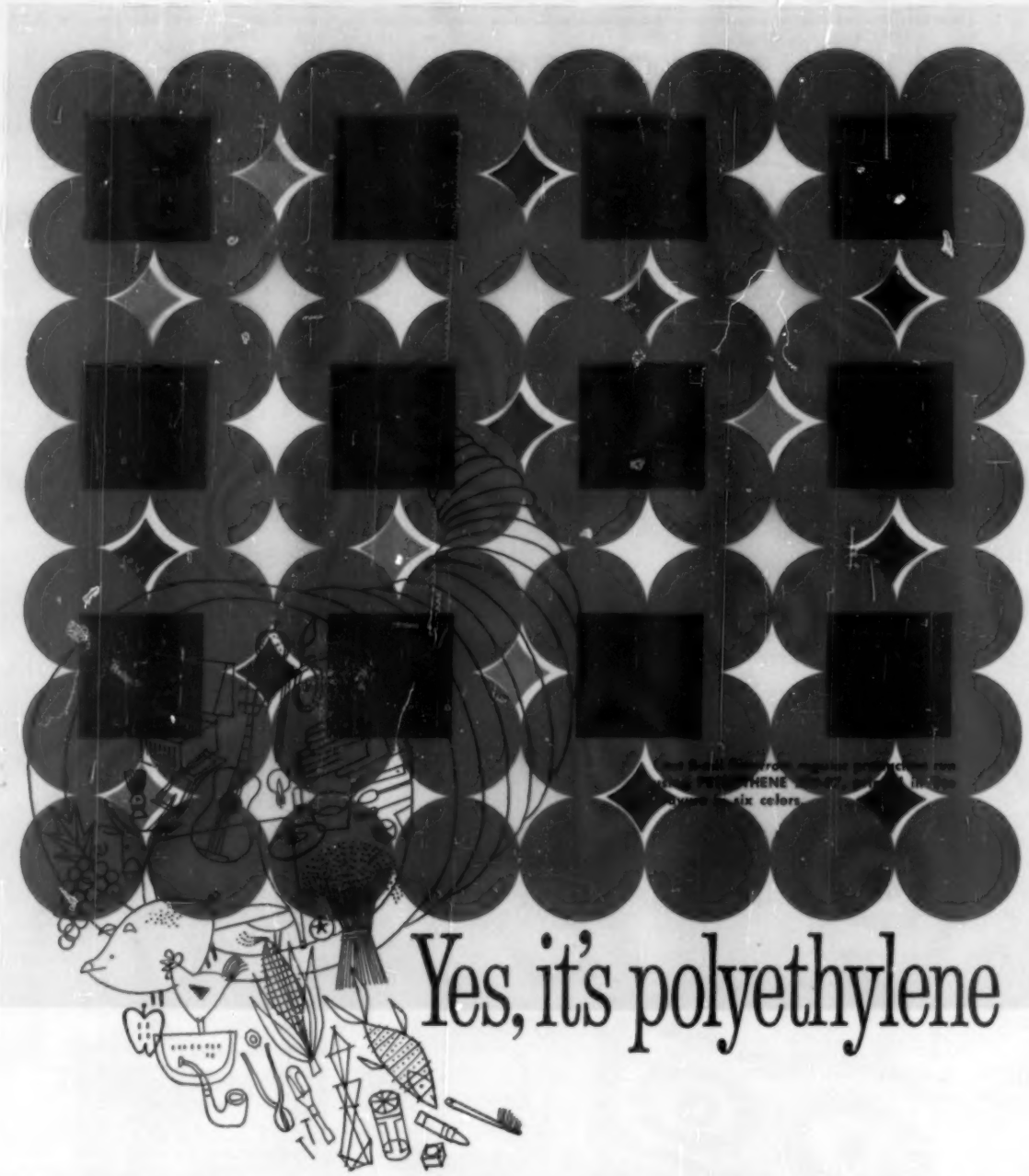
The city of Cleveland has amended its building code to permit the use of plastic pipe for street-to-house water service lines. The decision was made after plastic pipe easily passed rigorous pressure, temperature and torsion tests.

Plastic pipe is considered ideal for street-to-house water lines, which do not involve high pressure or extreme temperatures. It costs half as much as copper tubing and costs less to install.

Air Flow Problems?

U.S.I. Technical Service has a portable air velometer capable of measuring up to 10,000 feet per minute. If you have a problem involving air flow, indicate this with your request for technical service so the U.S.I. engineer can have the instrument available when he calls.





Yes, it's polyethylene

When you add brilliant printability to the clarity, toughness, and other well-known advantages of polyethylene, you can offer your customers a packaging material that will work as a powerful merchandising tool for their products. Polyethylene film can be economically printed with clear, bright colors at high speeds and with sharp registration and good ink adhesion. Packages can be formed on automatic machinery — sealed by heat-sealing or with adhesives.

Opens New Packaging Film Markets

With package designs that combine sparkling, multi-colored printing with polyethylene film's clarity, you can open up new packaging and merchandising opportunities for your customers. Printed film is now being used for dry-cleaner garment bags, produce packaging, soft goods overwrap, dairy and meat packaging, laundered shirt packaging, and many other applications where visibility, eye-catching color, and protection can be combined in a single package to give maximum sales appeal to the product.

In supplying film for this growing market, keep in mind the special advantages of U.S.I. PETROTHENE® polyethylene resins: excellent drawdown properties . . . superior toughness/clarity ratio in finished film . . . wide selection of resins ideally suited for clear or printed packaging film. Contact your nearest U.S.I. sales office for information.

U.S.I. is helping to expand your polyethylene film market with ads, similar to this one, addressed to the produce, food, dry-cleaning, and other package-using industries. These ads are designed to pre-sell your potential customers on the sales appeal and other advantages of polyethylene film packaging. To receive reprints of this advertising as it appears, write:

U.S.I. INDUSTRIAL CHEMICALS CO.
Division of National Distillers and Chemical Corp.
99 Park Ave., New York 16, N.Y.
Branches in principal cities

U.S.I.

Vol. III, No. 6

POLYETHYLENE PROCESSING TIPS

PRINTING ON POLYETHYLENE FILM: HOW TO SURFACE-TREAT FOR GOOD INK ADHESION

Because printing inks adhere poorly to untreated polyethylene film, it has been necessary to develop surface-treating techniques in order to print satisfactorily on this important packaging material. These techniques fall into two general categories – chemical treatment and physical treatment. Both have the effect of polarizing the surface of the film, making it receptive to ink which then becomes bonded to the film and cannot be removed by rubbing.

Chemical treatments which have been developed and tested to date are more costly and difficult than are physical treatments recently perfected. Consequently, this discussion will be devoted to physical means of treating polyethylene film; equipment and techniques developed to achieve the best possible results; and the problems which may be encountered by the processor during treatment.

Flame And Electronic Treators

There are two physical methods of preparing polyethylene surfaces for printing – flame and electronic treatment. While flame treatment gives excellent results, it is not as easily adapted to in-line operation, and thus is employed less in commercial practice.

Electronic equipment is used most commonly by the processor. It is relatively inexpensive, is easily adapted to in-line procedures, and is capable of giving satisfactory treat at roll speeds up to 300 ft./min. The degree of treat is a function of throughput rate and of intensity of treatment.

Most electronic treaters convert 115 volt, 60 cycle power into much higher frequencies and voltages to produce a high electrical potential across the film. The discharge of this electrical potential effects desired treatment and makes the polyethylene surface receptive to decorative matter.

Problems In Electronic Treating

Equipment, film, resin – all represent problems for the processor during surface treatment. Electronic treaters increase the static charge on the polyethylene film surface which must be bled off by a combination of brush and transformer type static eliminators. Such treaters also give off ozone during operation, so that adequate ventilation must be provided around the equipment.

It has been found that the presence of additives in the film interferes with surface treatment. Slip additives, lube oils, antistatic agents, antioxidants and antiblock agents all present problems. It seems that most of these materials tend to "bloom" or come up to the surface where they hinder treatment.

Consequently, films with high additive contents must be treated under more drastic conditions or at slower speeds. Ideally, they should be treated in-line as close to the blown film die as possible and printed immediately thereafter.

The type of polyethylene resin used is also a factor. Low-density resins treat more easily than higher density resins.

Tests For Degree Of Treat

Several methods have been devised for determining whether the film is being adequately treated for printing. Of these, the Scotch Tape test is most commonly employed as a quick test for control purposes. Here the treated film is printed using a standard ink and tape is applied to the print after drying. The tape is then drawn back slowly over about half its length and rapidly pulled off the remaining area. Treat is satisfactory if no ink is removed from the film.

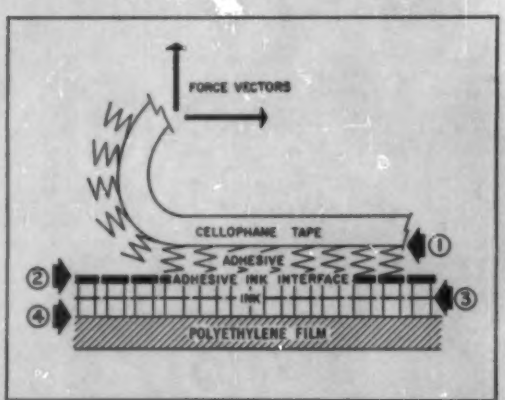


Diagram illustrates the four bond ruptures possible in the Scotch Tape test: (1) tape-adhesive rupture; (2) adhesive-ink rupture; (3) ink-ink rupture; (4) ink-polyethylene rupture.

U.S.I. Will Advise

The many factors involved in treating polyethylene surfaces for printing require careful consideration. As a manufacturer of polyethylene resins, U.S.I. has studied many phases of the subject and is equipped to help the processor find adequate solutions to his problems.

U.S.I. INDUSTRIAL CHEMICALS CO.
Division of National Distillers and Chemical Corp.
99 Park Ave., New York 16, N.Y.
Branches in principal cities

HOW TO INCREASE YOUR MARKET FOR MOLDED POLYETHYLENE PRODUCTS...

We all know what a good plastic material we've got in polyethylene. It's durable, attractive and economical. But remember—the sales appeal of molded polyethylene products is based on SERVICEABILITY. In the long run, the size and growth of your molded polyethylene market depend on how well you build quality into your products. It's not an easy job. Here are a few typical problems that molders encounter frequently, and some of the suggestions that U.S.I. technical service people have come up with:

LOW TEMPERATURE FLEXIBILITY

Understandably, there's little market future for polyethylene garbage cans that shatter on a cold winter's morning. The secret of getting good low temperature flexibility lies in proper resin choice. Look for resins with low density. As far as melt index is concerned, the lower the better for low temperature flexibility—providing the resin can be molded without going to pressures that will cause locked-in stresses. Avoid unrelieved stresses caused by poor design or molding techniques. And use-test your finished product—theoretical resin brittleness values may not mean much under practical conditions.

Recommended PETROTHENE® resins: 202, 203, 206, 207.

STRESS CRACK RESISTANCE

Why will a polyethylene carboy safely carry sulfuric or hydrofluoric acid, while a housewife's dishpan may split from the chemical effects of ordinary household detergent? The answer again involves stress and choice of resin. Specifically, resins of higher molecular weight or lower melt index, and polyethylenes of narrow molecular weight distribution, such as Petrothene resins, have less tendency to crack under environmental stress. Residual strains left after molding will also have a marked effect on stress crack resistance.

Recommended PETROTHENE® resins: (for housewares): 200, 203, 205, 207.

SHRINKAGE AND WARP RESISTANCE

Molded products are moving into new markets where dimensional accuracy and stability are essential. Warpage in flat items, such as drainboards and large covers, is chiefly affected by molding conditions. However, resins of lower density and lower average molecular weight will have slightly less tendency to warp. Shrinkage, too, is a result of molding conditions, especially temperatures, but here again resins of lower density are less subject to shrinkage.

Recommended PETROTHENE® resins: 201, 202, 203.

For advice on specific molding problems and resin selection, contact U.S.I. Technical Service.

HERE'S HOW U.S.I. HELPS YOU TELL YOUR CUSTOMERS ABOUT THE MARKET ADVANTAGES OF QUALITY IN POLYETHYLENE PRODUCTS

In a series of ads like the one at left and in an illustrated booklet, "The Goose that Laid the Golden Egg," U.S.I. is presenting to buyers of housewares and other molded polyethylene products the reasons why quality is their best market booster. The ads and booklet emphasize the importance of well designed, well molded, serviceable products in maintaining consumer confidence in polyethylene. The program is designed to help tell your customers the advantages of dealing with you, the quality molder. Reprints of these ads and copies of the booklet for you to send to your customers may be obtained by writing to U.S.I.

U.S.I. INDUSTRIAL CHEMICALS CO.

Division of National Distillers and Chemical Corporation

99 Park Avenue, New York 16, N. Y.

Branches in principal cities

Edited by Thomas A. Bissell
SPE Executive Secretary

NATIONAL ACTION

Professional Activities in SPE—PAG and PAC

Provision was made by our Society's founding fathers for groups of members to work on common problems of specific phases of plastics under the name Professional Activities Groups (PAGs). Until recently, this category of scientific endeavor existed only on paper. Since the birth of the first PAG in 1956, the following groups have been established: Plastics in Building; Plastics in Electrical Insulation; Extrusion; Reinforced Plastics; Injection Molding; Metals for Plastics Molds; Casting and Plastic Tooling; Forming; Finishing; Thermosetting Molding; Fabricating; Vinyl Plastics; Polymer Structure and Properties; Standards for Reporting Properties.

Several PAGs have developed worthwhile work programs and are actively achieving their goals. Other PAGs have developed constructive programs, but are hampered by the apathy of many members; the few members who are working have more than they can do. Other PAGs have been inactive. Still others, newly created, have not yet had an opportunity to develop programs and *modi operandi*.

The SPE Executive Committee met with officers of the various PAGs in New York on September 17, to discuss means for achieving more rapid progress in the PAGs. Problems concerning scopes, work programs, membership, relations with other groups, meetings, communications and secretarial assistance were discussed.

Before any group can begin to function effectively, it must have a scope. The scope should clearly indicate the area of plastics science in which the group intends to work.

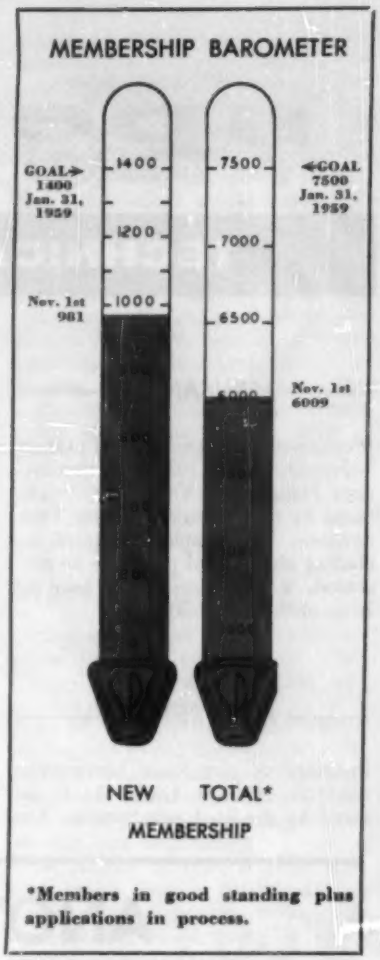
It is planned to have tentative scopes for all groups available for final approval at the meetings in January. The scopes are implemented for action by the work programs which reflect in detail the immediate interests of the group. Some PAGs have work programs already. It is planned to establish work programs for all PAGs before or at the January meeting.

SPE has agreed to work on test methods and standards for materials in cooperation with ASTM Committee D-20. PAGs are invited to work with Committee D-20. Since D-20 does little work on end products, PAGs interested in such topics should initiate work therein.

Active groups should have many working members. It seems self-evident from the purpose of the Society that each member of SPE should be working on at least one PAG. It is believed that more members will work on PAGs if this activity is brought to their attention. These interested are requested to contact the writer.

The Professional Activities Committees (PACs) of the various Sections are organized to assist Sections in developing their scientific endeavors. PACs, in addition, can and should undertake particular phases of the work programs in PAGs. Any PAC interested in a topic under a particular PAG should make arrangements with the PAG. The PAG will coordinate the work on a National level. Several PACs, each working on specific topics under a PAG, could produce worthwhile results that would add to the stature of SPE.

Good communications are vital to effective PAG operation. It is suggested that those listed as members of a PAG in which they are not interested notify the Chairman so that their names may be removed from the list. The membership list will then show the real working interest.



*Members in good standing plus applications in process.

The SPE National Office can expedite communications; the staff is able and glad to render many auxiliary clerical services. Chairmen of PAGs need only to request help of this nature.

To increase your participation in this field, select the PAG on which you wish to work, notify me, and come to the meeting in January in New York. (A full schedule of PAG meetings held in conjunction with the 15th ANTEC will be published in the January issue of the *SPE Journal*.) Be prepared to elect good workers and leaders as officers of your PAG. Work on some phase of the program you help to establish.

Frank W. Reinhart

Dr. Frank W. Reinhart
Administrator, PAG

spe

TECHNICAL MEETINGS CALENDAR

15TH ANTEC

WORLDWIDE ADVANCES IN PLASTICS—January 27-30, 1959, The Commodore Hotel, New York City. Sponsored by the Newark and New York Sections. The complete program, including abstracts of papers to be presented, will appear in the January issue of the *SPE Journal*.

1959 RETECS

PLASTICS IN THE SHOE INDUSTRY—April 21, 1959, St. Louis, Mo. Sponsored by the St. Louis Section. For information write to Robert S. McDorman, Plastics Molding Co., 4211 N. Broadway, St. Louis, Mo.

PLASTICS IN THE METAL INDUSTRY—May 7, 1959, Penn-Sheraton Hotel, Pittsburgh, Pa. Sponsored by the Pittsburgh Section. For information write to John Parks, Hydraulic Press Mfg. Co., 512 Empire Bldg., Pittsburgh 22, Pa.

PLASTICS FINISHING—October 18, 1959, Niagara Falls, N.Y. Sponsored by the Buffalo Section with the cooperation of the Plastics Finishing PAG. For information write to Gordon K. Storin, 3 Forest Rd., Lewiston Heights, Lewiston, N.Y.

VINYL PLASTICS—Autumn, 1959, Cleveland, Ohio. Sponsored by the Cleveland-Akron Section. For information write to W. D. Martin, 12333 Chippewa Rd., Brecksville, Ohio.

SECTION MEETINGS

PITTSBURGH—December 20, 1958, Churchill Valley Country Club. Annual Christmas Party.

★ ★ ★

ANOTHER NEW IMPCO

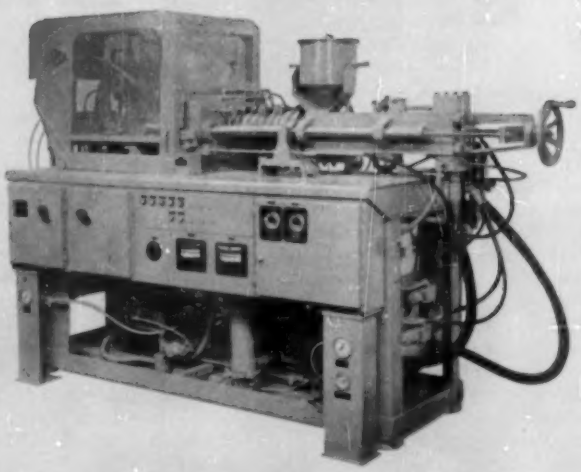
Special Purpose Injection Molding Machine for Containerlike Molding

MODEL

CA30-75

- 30-50 gram capacity
- 30 molding cycles per minute*
- shut-off nozzle for pre-pressurized molding
- simplified mold construction
- built-in die and platen cooling arrangement
- separate injection and clamp hydraulic circuits
- shock mounted control panel
- photo electric recycling monitor
- 75 ton clamp
- 9¼" stroke
- fully automatic

*dependent on material and mold construction



IMPCO IMPROVED MACHINERY INC.

NASHUA · NEW HAMPSHIRE

In Canada, Sherbrooke Machineries Limited, Sherbrooke, Quebec

COMMITTEE REPORTS

Publications

Chairman E. C. (Gene) Quear reports that two meetings have been held recently, with SPE staff personnel in attendance, to establish operating policies for the Journal and to discuss policy and problems in the entire publications area.

Results to date have been very encouraging. A resume of committee activities follows:

1. A Publications Committee Task Group (Parke Woodworth, Jay Kuhn and Milt Brummer) is working closely with the Education Sub-Committee on final details of the Engineering series book "Processing of Thermoplastic Materials".

2. New advertising rate cards are now in effect.

3. New art-work on headings for Journal features and use of more color throughout will soon be apparent.

4. Guideposts for rating technical papers—for publication, have been provided for the Advisory Editorial Board.

5. Guideposts for Section News Reports have been sent to Local Sections.

6. A new type of Journal stitching is now in use (do you like it?)

7. The 15th ANTEC preprint book will be 8-1/2 x 11 inches (old size was 5-1/2 x 8-1/2 inches). Price will be $7.50 for members and $12.50 to non-members. Member registration fee of $15.00 will include one preprint book.

8. Journal Feature Editorials are to be stressed. Your Journal will not exceed 40% advertising, according to present policy.

The Publications Committee requested the National Council to pass a resolution discouraging Sections from soliciting advertising for Section publications since it believes such practice to be aganist the best interests of both the individual section and the society as a whole. (Ed's. note: Such action was passed by National Council action on September 19, 1958, with provisions for financial assistance to the individual section, if necessary, and justified).

Reasons for this recommendation, based on experience of related engineering societies, follow:

1. Advertising would have to be solicited from many of the same organizations and individuals that already are supporting the SPE in many ways, such as Company Registration at ANTEC, advertising in the SPE Journal and sponsoring various Section activities.

2. Experience of other societies indicates a strong tendency for Sections to solicit advertising on a "contribution" or "help-us-out" basis rather than "for value received". This results in complaints of "pressure" or "black-jack" solicitation from advertisers and prospects.

3. Even though Section publications are local and the SPE Journal, national, they would compete for the same budget dollar of many advertisers. Thus advertising in Section publications would hinder sale of Journal advertising upon which the Society depends importantly for its operation, growth, and Section and Member services.

4. Even though the advertising potential of SPE Section publications may seem insignificant at present, volume has grown in older engineering societies to an annual gross as high as $15,000, most of which is national advertising.

Membership

Chairman Frank W. Reynolds reports that, in conformance with Council action of June 20, 1958 (i.e., to drop all delinquent members as of June 30, 1958), letters were mailed on July 10 to 310 delinquents in 35 different sections advising them that they have been removed from the rolls of SPE. To date, no significant reaction has been noted.

On August 1, 1958, a letter was sent to all Section Presidents requesting the individual Section to establish a practical quota for membership increase (suggested 25%). Replies to this letter have been disappointing to date, but are picking up as the fall season progresses.

The results of the membership drive through August 29, 1958, show a total overall average increase of all Sections to be 11.9% or a total of 669 new members. They represent 47.5% of quota.

PUBLICATIONS COMMITTEE—Left to right: M. L. Brummer, L. A. Bernhard, L. R. Noe, T. A. Bissell, E. C. Quear, R. K. Gossett, P. Woodworth, C. E. Rhine, J. H. Day. Not in picture: C. D. Kacalieff, J. H. Kuhn, G. B. Thayer.

Education

Bob Bartlett, Chairman, reports that NEC is corresponding with the various Sections in an effort to stimulate educational activity work at Section level and to solicit comments on the Guide Book.

Progress of the work on the SPE series is as follows:

A. Book No. 1 (Vol. I) "Quality Control for Plastic Engineers"—Published and available.

B. Book No. 2 (Vol. II) "Processing of Thermoplastic Materials"—in current publication processing and soon to be available.

C. Book No. 3 (Vol. III) "Processing of Thermosetting Materials"—in active planning stage.

D. Book No. 4 (Vol. IV) "Design of Plastics Parts"—is also in the planning stage.

A report is being prepared for the guidance of future editors, based on the experiences gained by this committee in the publication of "Quality Control for Plastics Engineers", as well as the present publication, "Processing of Thermoplastic Materials".

Boy Scout Merit Badge on Plastics

Of interest to all Local Sections of SPE is the current goal of developing a Boy Scout Merit Badge on Plastics. To handle this activity, a Subcommittee headed by Karl F. Plitt, of the Washington, D. C. Section, has been established within the National Education Committee for your Society. This Subcommittee is cooperating with the Boy Scouts of America to develop the requirements for a merit badge intended to disseminate knowledge of plastics and to interest youth in careers in the plastics industry. Similar merit badges already exist on chemistry, photography, textiles, leathercraft and more than 100 other subjects. Since the Scouts now have a boy membership of more than 3 million and expect to reach 5 million by 1965, there is quite an opportunity to achieve this goal.

To assist the Boy Scouts of America in organizing a merit badge on plastics, this Subcommittee must devise a number of simple experiments or projects using materials and equipment that any boy may easily obtain.

All members of SPE are invited to exercise their imagination and ingenuity in devising plans or outlines for experiments depicting the properties of plastics—or how to build useful items. Suggested materials might include dry shellac, gelatin, egg white, old photographic film, discarded household items made from plastics, casting resins from hobby shops and many other sources. Equipment might be based on common home workshop tools, electric irons, plaster molds, the kitchen stove, C-clamps and many others.

Any member of the SPE who has ideas for plans for simple plastic projects can assist in this work of your Society by sending the information to Mr. Karl F. Plitt, U. S. Department of Commerce, National Bureau of Standards, Washington 25, D. C.

EDUCATION COMMITTEE—First row, left to right: T.A. Bissell, J.L. Formo, C.C. Winding, J.W. Lindau, R.C. Bartlett. Second row, left to right: H.S. Nathan, K.F. Plitt, H.A. Gadd, E.S. Bloom. Not in picture: J.M. Church, A.G.H. Dietz, B. Maxwell, L.H. Hitchcock, N.A. Skow, E.A. Haddad, A.J. Monack.

Inter-Society Relations

G. Palmer Humphrey, Administrator, has indicated that copies of reports submitted by the various Inter-Society Relations Chairmen may be obtained by making formal request to your National Office.

Of specific interest to all SPE members is the work of the International Standards Organization (ISO/TC61). The Eighth International Meeting was held in Washington, D. C., November 3 to 8, 1958. Dr. Norman A. Skow is the SPE liaison for ISO/TC61 for Plastics.

The work of ISO/TC61 for Plastics does for the international plastics world what ASTM does for the American plastics industry. SPE has contributed financially to support this work.

Professional Activities Groups

Dr. Frank W. Reinhart, Administrator, wishes to remind SPE members that meetings of all Professional Activities Groups (PAG) are scheduled to be held during the 15th ANTEC in New York City(January 27 to 30, 1959, at the Hotel Commodore). Your active participation is solicited.

Credentials

Chairman George Baron reports that during the summer months (June through August) each member of the committee, individually, has carefully checked a total of 314 new applications for membership in SPE plus 7 requests for reclassification.

These applications were received from the National Office in 13 separate mailings. Processing of the applications requires remailing to each individual committee member, and processing of each mailing was accomplished and re-routed to the National Office in from 8 to 15 days.

The new applications were classified as follows:

Professional	44
Member	197
Associate	68
Junior	3
Returned to Section for more information	2
Total	314

The reclassifications were:

Professional	5
Member	2
Total	7

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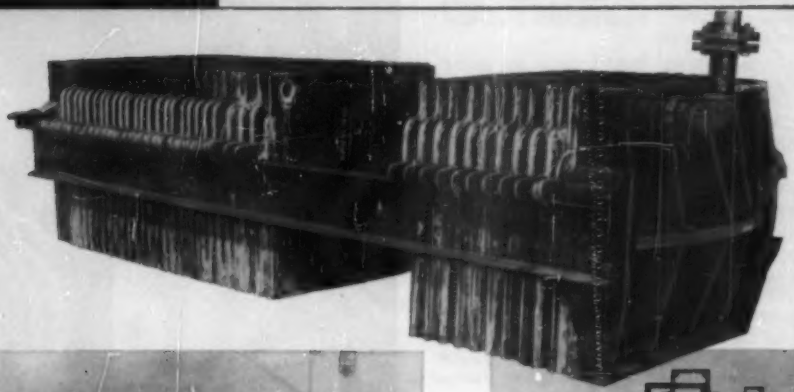

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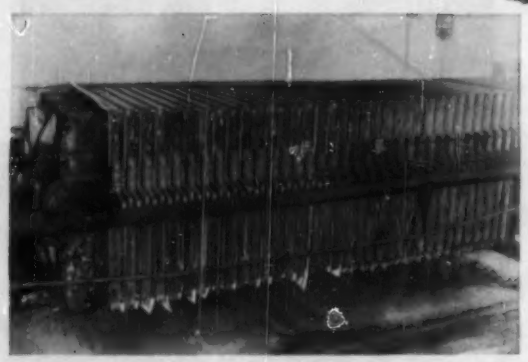

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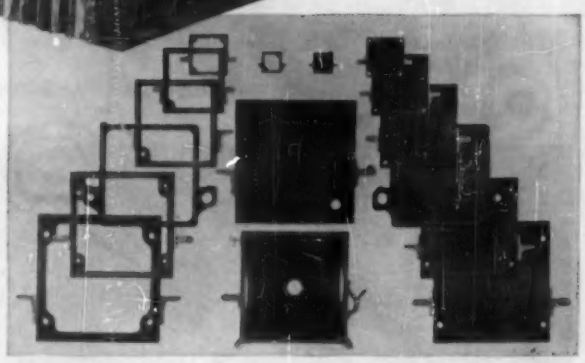

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SECTION NEWS

Akron

Organization Meeting

Frank A. Martin

The Akron Section held an organization meeting October 27 to elect officers and committee members. Although not yet officially recognized as a Section, the group will submit a petition for its Charter to the National Council in January. Officers elected are: Don Siddall, President; Dick Juve, Vice President; Howard Nicol, Secretary; and Milan Krajcik, Treasurer. No National Councilman has yet been elected. Section Directors elected are: Wayne Anderson, Don Siddall, Milan Krajcik, Chuck Wolk, Frank Martin, Foster Young, Richard Juve, Donald Lewis and W. H. Nicol. A Program Committee consisting of Lester E. Giga, Chairman, Dick Juve and Tony Urbanic was appointed. Foster Young will serve as Chairman of the Membership Committee, and Wayne Anderson as Chairman of the House Committees. Other committee selections were deferred.

SPE National Secretary George W. Martin outlined the current program and ultimate aims of the National organization. He also stressed the importance of close communication between each Section and the National Society.

The second item on the program was an excellent film produced for the Texas Company entitled "Hydraulics." The film explained the various requirements of oils and very effectively illustrated the importance of each point in oil specifications and the various additives.

The program was concluded by Soren Graae of Blow-O-Matic Corp. who showed a short film of their new Danish-built blow molding machine in action. He supplemented this film with commentary on the uses of blow molding techniques and future applications.

Southeast New England

Hydraulics and Blow Molding

Glenn A. Tanner

A full program was presented for the October meeting which was held at Pawtucket Country Club. This was the last regular meeting until January due to conflicts with the National Plastics Exposition, Thanksgiving, and the events preceding Christmas.

Northern Indiana

Polyester and Epoxy Resins

S. Michalski

The October meeting, held at the Chamber of Commerce in Fort Wayne, was opened by the President, Charles E. Shafer, who appointed Roland Smenner as temporary Secretary-Treasurer. The present Secretary-Treasurer expects to be transferred East in the near future. Mr. Shafer also mentioned that thought should be given to the selection of an "Engineer of the Week."

Guest speaker was Harvey Lieberman of Nuodex Products Co. He presented a talk on polyester and epoxy resins.

Binghamton

Epoxy Resins

Leo J. Pranitis

The Section held its September meeting at the Paramount Lounge. President Emery Slaght introduced new members to the group. SPE National Secretary George Martin and Treasurer G. Palmer Humphrey spoke on National news and plans.

Technical speaker for the evening was Jerome D. Bassin of Borden who covered epoxy resins from their history, through their chemistry and up to their present and proposed applications. His presentation was closed with the display of various samples of epoxy applications.

Central New York

Vinyl Dispersions

Frederick E. Ruhe

The October meeting was called to order by President Jim Lampman who introduced G. Palmer Humphrey, SPE National Treasurer, Mr. Humphrey spoke of the activities of National Headquarters and made some excellent suggestions for the Section.

The speaker of the evening, Emery Slaght of Stanley Chemical Co. and President of the Binghamton Section, presented "A Thumbnail Sketch of Vinyl Dispersions." He described slush molding, cavity molding, slush coating, and physical and chemical properties. Mr. Slaght was of the opinion that plastisols show great prospects for an expanding future.

Pittsburgh

End Uses of Plastics

John E. Parks

The September meeting was held at the Sherwyn Hotel, new meeting place for the 1958-59 season. Frank Martin, of the Cleveland-Akron Section, spoke on "End Uses of Plastics at the Hoover Company." Mr. Martin directs the engineering of all plastics parts used by Hoover.

New York

Polycarbonates, Fillers and Heat Cutting

Charles C. Orr

Minus its REPPAG, which for convenience sake now meets separately, the New York Section met October 15 at the Governor Clinton Hotel with nearly 150 members and guests in attendance. Following dinner and a plea by Section President George W. Leaf for member cooperation to expedite the coming ANTEC, the various groups broke with the main body to attend their separate meetings.

Featured at the regular meeting was a discussion on "Lexan Polycarbonate Resins" by Richard J. Thompson, General Electric Co. A thermoplastic polymer suitable for injection molding and extrusion, this resin is the first commercially useful material to incorporate the carbonate radical as an integral part of the main polymer chain. G. E.'s formulation is a reaction product of diphenyl carbonate and bisphenyl A (2,2-bis [4-hydroxyphenyl] propane).

The Vinyl Sub-Group (VIPAG) held a panel discussion on "Fillers for PVC Compounds" which was moderated by Andrew D. Varenelli, General Electric Co. Panelists included William A. Moore, Philip Carey Mfg. Co.; Larry Jacobson, Diamond Alkali Co.; and Emil Schwartz, Southern Clays, Inc.

Speaking on "Fillers in Vinyl Insulations and Jackets," Mr. Varenelli pointed out that fillers should be free of impurities, have a low oil absorption number, disperse readily and not agglomerate. In vinyl insulations and jackets, fillers are used to improve insulation properties and surface appearance, facilitate extrusion, and decrease the marring tendency of the plasticizers. While inexpensive, fillers should not be used indiscriminately since an excess or the wrong type will impair the properties of the end-product.

Mr. Moore discussed "Asbestos Fillers," stating that although available in six basic types, the chrysotile form is recommended for use in vinyl formulations. Asbestos fillers improve cohesive properties during extrusion and calendering, and give less sag when used in plastisols.

Mr. Jacobson spoke on "Calcium Carbonate Fillers," describing their effects on the cost and physical properties of PVC compounds. He indicated that calcium carbonates lower compound costs, improve processing characteristics and yield better end products.

"Use of Clay in Vinyl Compounds" was described by Mr. Schwartz who presented data showing the basic values of calcined clays with respect to the electrical stability of vinyl insulation. These clays mixed with normal kaolins yield products with uniform tensile properties and improve scuff resistance. In paste formulations they promote good viscosity control and foster dry surface fusion and no-sag characteristics.

Addressing the Thermoformers Sub-Group, Joseph Swick of Trono-Matic, Inc., discussed "Heat Cutting of Formed Plastics Sheets." After pointing out that tensile, shear and compressive strengths enter into any cutting problem, he went on to discuss the two methods by which heat cutting is accomplished. In one case the steel rule die is heated by conduction from electrical resistors located in its carrying plate; in the other the die is secured to the bed plate and the plastics is heated when the hot plate comes in contact with it. In blister packaging the cutting operation is usually so fast that the heat will not distort the blister.

Newark

Injection Molding

F. W. Ducca

The September meeting was well attended. In addition to the usual presentation on a topic of interest in plastics, the meeting was featured by the presence of SPE National Officers. President R. K. Gossett, Treasurer G. Palmer Humphery and Executive Secretary Thomas A. Bissell each addressed the Section and discussed the aims of the Society.

Saul Blitz moderated a panel discussion on injection molding. Panel members and their topics were: David J. Sloan, Lester Phoenix, Inc. —Internal Manifolds; Ed Fitzpatrick, F. J. Stokes—Automatic Runner Systems; Frank Z. Bailey, Improved Machinery, Inc.—External Multiple Nozzles; and Harold L. Hoy, Jr., Helmuth Tool and Die—Hot Runner Mold Designs. After the panelists presented their topics, the members of the Section participated in a question and answer period.

North Texas

Small Businesses

David A. Daniels

The Section met September 22 at the Cattlemen's Cafe in Fort Worth for dinner and a program. Guest speaker of the evening was Glen Facka, vice president of the Republic National Bank in Dallas who discussed the problems of small businesses.

Central Ohio

Refrigeration and Plant Tour

Gary C. Fulmer

The September meeting was held at Ricardo's Restaurant. The wives of members were invited. After a short business meeting, Royal Buchanan, manager of the Advanced Engineering Section at Westinghouse Electric in Columbus, spoke on Freon as used in modern refrigeration. He brought with him considerable equipment for use in demonstrating Freon's properties.

The October meeting was held at Presutti's Villa. Following dinner and a short business meeting, the Section was conducted on a tour of the Industrial Nucleonics Corp. The tour, led by George I. Doering, manager of the Chemical Industries Div., consisted of seeing demonstrations of Accuray equipment and the Accuray assembly plant.

New York

Strength Properties of Reinforced Plastics

George Lubin

The Reinforced Plastic Sub-Group (REPPAG) of the New York Section held its October meeting at Grumman Aircraft Engineering Corp. in Hicksville, L. I. Guest speaker was Dr. Albert G. H. Dietz, outstanding authority on reinforced plastics from Massachusetts Institute of Technology whose topic was "Determining the Strength Properties of Reinforced Plastics." Dr. Dietz explained that research into strength properties is proceeding in three principal directions: correlation of tensile and compressive behavior of reinforced plastics with the flexural behavior; deviations from linearity of stress to strain behavior of reinforced plastics when loaded at angles other than those corresponding to the principal or natural axes; and studies of bond behavior of glass against polyester and epoxy type resins.

In the accompanying photograph, from left to right, are George Lubin, plastics consultant at Grumman; Dr. Dietz; and John Meirs, chief of Structures Dept., Grumman.

Ontario

Linear Polyethylene

Harry E. Watson

Canada lags behind Europe in finding new end uses for linear polyethylene, according to Dr. E. W. Grams, German scientist, who addressed the Ontario Section recently. Dr. Grams, Farkwerke-Hoechst Chemical Co., West Germany, was touring Quebec and Ontario to exchange ideas with fabricators and processors on linear polyethylene applications.

Linear polyethylene in Europe has proved a special success in articles for household, farming and camping equipment. The most important field is in injection molding, with extrusion and blow molding next.

Dr. Grams supplemented his talk with a colored movie showing fabrication methods, end uses and a method of butt welding.

Central Indiana

Ladies' Night

W. P. Miller

The September meeting was designated Ladies' Night and was held at the Warren Hotel. A social hour and dinner preceded an informal discussion given by the vice president of the local radio and television station, Eldon Campell. He explained the make-up of a television show, problems in trying to satisfy the public, and some of the things which happen behind the scenes whenever a break occurs in some of the relay or transmitting equipment.

Kentuckiana

Nylon 6

R. O. Carhart

The October meeting began with a short business meeting in which Ed Roberts, the Section's representative to the Louisville Engineering and Scientific Societies' Council, gave a short report on the educational guidance work being conducted in the Council. Announcement was made of nominations for Section offices left vacant by the division of the Section.

Speakers for the evening were D. L. Duncan and R. B. Wolfe of Spencer Chemical Co., who gave an informative talk on nylon 6. Their discussion covered a general comparison of the different types of nylon, following which design considerations, processing characteristics and applications for nylon 6 were reviewed.

Detroit

Plastics in Building

Frank S. Marra

The October meeting was held at Stouffer's Restaurant at Northland. The speaker was George E. Murray, Plastics Technical Service, Dow Chemical Co. His presentation pointed up the advances made by plastics in the building industry, not as substitutes, but as established materials which can do jobs better than other materials or just as well for less cost.

Southern

Credit Policies

S. F. Rutland

The September meeting was held at the Architects and Engineers Institute in Atlanta. Guest speaker was M. L. Madway, Plastics Department Credit Supervisor of Rohm and Haas. He presented an interesting program based on the statements from a large number of fabricators, molders and distributors throughout the Country. Mr. Madway discussed the division of the sales dollar and the general credit policies of materials suppliers.

The regular meetings of the Section are now being held on the third Friday of each month.

Miami Valley

Mold Designing

Leo Kruskamp

The September meeting of the Miami Valley Section featured two speakers. Dr. Hailstones, professor of Economics at Xavier University, explained the economic theories of the business cycle. Bill Evans, a member of Miami Valley, spoke on reducing mold costs and improving quality through planning methods.

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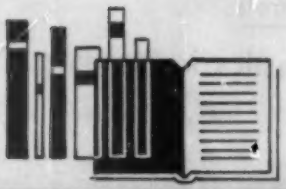


BOOK REVIEWS

Adhesives and Sealants in Building, Publication 577

Building Research Institute, Washington, D. C., 1958. 160 pp., $5.00.

This book contains twenty complete papers presented at the 1958 Conference Proceedings of the Building Research Institute and Building Research Advisory Board. The papers cover the practical aspects of adhesives and sealants in the building industry and are followed by panel discussions on each paper.

The scope of the conference is best illustrated by listing the subjects of the papers presented: 1. Adhesives. 2. Sealing Compounds and Tapes. 3. Preformed Gasket Materials and Tapes. 4. Pressure Sensitive Tapes. 5. Glazing Light-Transmitting Materials. 6, Calking Compounds. 7. Sealing Compounds and Gaskets. 8. Butyl Compounds for Curtain Wall Sealants. 9. Adhesives for Floor Surfacing Materials. 10. Adhesives for Walls, Ceilings, and Work Surfaces. 11. Adhesives and Sealants in Buildings' Service Systems. 12. Bonding Agents for Cementitious Materials. 13. Wood Laminated Structural Members. 14. Glued Structural Members. 15. Types of Adhesives for Sandwich Panels. 16. Skins, Cores, and Fabrication of Panels. 17. Structural Adhesives for Metals. 18. Adhesives for Plastics. 19. Tapes for Building Panels. 20. New Adhesives for Wood. These papers contain many tables of physical properties and illustrations of the various adhesives and sealants described therein.

W. R. Lawton

Unit Processes in Organic Synthesis, Fifth Edition

P. H. Groggins, Editor-in-Chief. McGraw-Hill Book Co., New York, 1958. 1070 pp., $17.50.

The fifth edition maintains the high standard set by its predecessors. Each subject is treated in depth by a qualified worker in that field; yet, enough introductory material is included that a good general grasp of the field can be gained readily by the novice.

The sections dealing with polymers and plastics are particularly well done. The Editor is to be congratulated upon his choice of authors. Special mention should be made of Chapter 15, Part 1. Hobenstein and Ullman have given in only 86 pages one of the finest introductions to polymer chemistry this reviewer has seen. For the plastics engineer seriously wishing to understand (in order to apply) the fundamentals of polymer chemistry, this presentation is worth the price of the entire book.

E. H. Merz
Monsanto Chemical Co.

Graphic Science

Thomas E. French and Charles J. Vierck. McGraw-Hill Book Co., New York, 1958. 758 pp., $8.50.

By considering graphics more as a science than an art, the authors succeed in convincing the reader that it is not too difficult to make useful drawings and charts after a reasonable amount of reading and practice. The book starts with routine fundamentals, reaching the most difficult problems in the last chapters.

The authors discuss the use of instruments for geometry, lettering and projection drawing. Also discussed is the technique, for drawing tools, instruments and manufactured items. More space is devoted to the geometry of straight and curved lines, planes, curved and warped surfaces, and to empirical equations and calculus. There is a glossary and an appendix containing bibliography, list of American Standards and other useful data. Illustrations include innumerable photographs, diagrams, charts and tables.

Although this book will not make every reader an expert in graphic science, it will help many engineers and will make the preparation of blueprints and patent applications considerably easier.

Dr. Louis C. Barail
Barail Associates

A Guide to Plastics, Second Edition

C. A. Redfarn, B. Sc., Ph.D., F.R.I.C. Philosophical Library, New York; Iliffe and Sons, Ltd., London. 150 pp., $7.50.

Here, in easy to understand text and charts, is a good reference to the basic types of thermosetting and thermoplastic compounds. Expanded in this edition to cover new advancements in the plastics field, the book is very well done.

The purpose of the book as stated by the author, is that of a condensed, non-technical guide. Chemical formulas are almost non-existent. The charts and flow sheets are a little hard to get used to at first, but on closer study offer advantages over others this reviewer has seen.

Five chapters covering nomenclature, raw materials, manufacturing of the plastics, fabrication, and properties, cover the field adequately.

A small bibliography is attached.

Written from the British viewpoint, some of the terms are different from ours, yet so easy to read is the book that anyone can understand it. It would be hard to suggest additions or deletions, yet it could be wished that more had been written about polyethylene and the carbonates. The data is much too scant on some of the types of plastics, however, this is more than compensated for by the variety of materials that are covered.

The basic course in the machinery and fabrication of plastics, Chapter 4, is very good. It, of course, doesn't go into too great detail, yet covers the field adequately. The final chapter, Chapter 5, deals with the British Standards for plastics and a brief definition of plastics properties finishes the chapter and the book. For those interested in a comparison with U. S. testing standards, the British list should prove invaluable.

All in all, well worth reading.

Frank D. Allen
L. H. Butcher Co.

★ ★ ★

ABOUT MEMBERS

Howard L. Burpo, Jr., has been appointed agricultural products manager, Union Carbide Plastics Co., (formerly Bakelite Co.). In his new position, Mr. Burpo will direct the sale and service of the company's vinyl agricultural products such as portable silos, ditch and pond liners, irrigation tunnels and tarpaulins. Mr. Burpo joined the company as sales trainee in 1945 and was made technical representative in 1947. Prior to his present appoinment, he was Eastern zone manager, film and sheeting, a position which he acquired in 1956. He is affiliated with the Newark Section of SPE.

H. L. Burpo

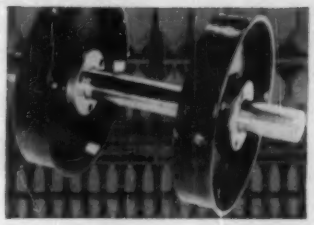
R. D. Sackett

Robert D. Sackett of the Western New England Section has joined Hartig Extruders, Div., Midland-Ross Corp., Mountainside, N. J. In his new position he will serve the New England area as sales engineer. Previously, Mr. Sackett was technical service associate with Monsanto Chemical Co., Plastics Div. In 1944, he received a B.S. degree in chemistry from Tufts College. Since December 1955, Mr. Sackett has been Editor of the monthly feature "Speaking of Extrusion" in the *SPE Journal*.

Dr. Raymond B. Seymour of the Southern California Section has been elected president and chairman of the board of Alcylite Plastics and Chemical Corp. Alcylite, formerly Loven Chemical of California, produces phenolic molding compounds, resins and chemical-resistant plastics cements.

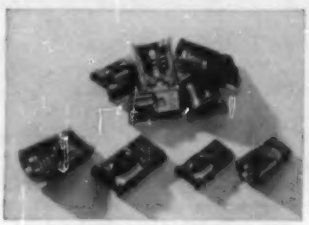
Harry L. Darby, vice president of Winner Mfg. Co., Inc., has been appointed vice-chairman of the Public Relations Committee for SPI's Reinforced Plastics Div. Mr. Darby is affiliated with the Philadelphia Section of SPE. Other appointments by the Reinforced Plastics Division are: **Clare E. Bacon**, manager of molder sales, Owens-Corning Fiberglas Corp., as chairman of Finance; and **James S. Lunn**, president of Lunn Laminates, Inc., as chairman of the Executive Committee. Both are affiliates of the New York Section of SPE.

PRODUCT-DESIGN BRIEFS FROM DUREZ



New phenolic cuts cost of impact parts

New sisal-filled phenolic, *Durez 18683*, brings cost of high-impact molded parts like these 10-inch pulleys down to about the cost of parts molded of general-purpose material. *Durez 18683* attains impact strength of 1.4 ft. lb/in.; molds by standard compression or transfer methods; cures fast. *Write for technical data.*



Fast cure spurs output of small parts

New split design and a fast-curing phenolic speed production of these lamp sockets. Threads are molded in, eliminating a threaded insert. A metal clip joins halves and connects wires, eliminating soldering. Halves are molded, 80 at a time, of general-purpose *Durez 265*, which cures in a few seconds. *For facts on this versatile phenolic molding compound, write today.*

Newest idea in closures: debossing

Once impossible, debossed designs perk up new molded plastic closures. An electroforming process solves problem of making undercut molds for debossing. Textured effects like leather and wood grain are possible. Durez phenolics, formulated to resist chipping, cracking, and bleeding, are used in these new closures. *For information on these compounds, write us.*

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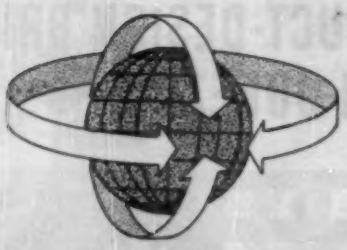

PLASTICS AROUND THE WORLD

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ITALY

MATERIE PLASTICHE

September, 1958

Abstracter: Alfred L. Alk

Plastics in Agriculture—R. Pozzo

This is a continuation of a series. Polyethylene is used to aid propagation of plants by: rooting of cuttings in beds covered by film; setting seeds, particularly tobacco, under polyethylene instead of gauze; air-layering under PVC and polyethylene; grafting with films replacing the usual wax preparations. Seeds may be planted in small bags instead of pots. Trees and shrubs are balled in reusable films rather than in burlap. Stock is whipped with roots wrapped in films. Earth and plants are fumigated under impermeable plastics covers. Ripening of fruits such as bananas and tomatoes is hastened and flower culture has been transformed using film for mulches and for light and heat control. Plastics are also used as soil conditioners, as fertilizers, in the preparation of agricultural products for the market and for the protection of workers in the field.

Copolymers of Vinyl Chloride—P. L. Sbrolli and L. Lucchetti

Part 1—Copolymerization — explains how vinyl chloride is copolymerized and with what other monomers. The discussion of equilibria, thermodynamic, requirements and chemical reactions is supported by graphs and tables.

Extrusion of Polymethylmethacrylates—I. Ronzoni and P. L. Chini

Normal block polymers of the methylacrylates used for preparing sheets and other articles are not adaptable for extrusion and injection molding by virtue of decomposition of depolymerization when processed at the required temperatures and pressure. However, by preparing other types of polymers it has been possible, without sacrifice of physical properties to produce resins which can be heated to working temperatures and viscosities without decomposition. The article gives operating details for extrusion with conventional and degassing equipment. Types of screws are examined and illustrated, as are typical tubing, sheeting and profile dies. Special directions for feeding and cooling are presented.

Synthetic Resins in the Leather Industry—M. Lenzini

The latest development of plastics sheets of limitless dimensions was directly competitive and detrimental to the use of leather. Now the industries have joined through treatment of leather with polymeric materials, particularly acrylics, to give unique and better properties to the natural product.

PVC in Flooring—M. Parducci

It is pointed out that the development of new types of flooring stopped 17 or 18 centuries ago, and since then we have had no additions to the art. The author examines the criteria for good floors. Common materials fail in many respects, ie. marble, terrazzo, tile, cement and the like are cold, hard and noisy. Wood is elastic and quiet, but hydrophilic and hygroscopic. It can rot and mildew. It breaks and wears. It is essentially discontinuous and collects dust and dirt. Rubber ages by oxidizing and vulcanizing. Linoleum is relatively delicate. It embrittles at low temperatures. It has slight resistance to alkalies and cleaning compounds and little abrasion resistance. PVC, however, apparently overcomes these objections and can be considered a new kind of universal flooring. It has the possibility of an infinite variety of colors and shapes and can be laid with a minimum of skill and manpower. It is usually applied to a firm, smooth substrate with specially formulated adhesives, commonly based on synthetic rubber.

Plasticizer Migration—A. Bonvicini and L. Caldo

The mechanism by which plasticizers migrate in PVC seems to be by weakening of polar bonds with the base resin and formation of stronger bonds in the substance with which it is in contact. Speed of migration depends both on resistance of the base resin and absorptivity of the contiguous material. When elastomeric and rigid PVC are placed together, migration into the less plasticized component takes place. Its speed depends on a variety of factors, in general, less migration from, and less absorption into, is shown by resins with high K values. Other physical and chemical factors, various plasticizers, mixtures, absorbants and test conditions are discussed and illustrated with graphs and tables.

★

GERMANY

DER PLASTVERARBEITER

June, 1958

Abstracter: Leo Fischer

Technical Testing of Styrene Foams—Dr. Fritz Stastny

Foamed styrene cannot gain a firm place in large industry until performance test techniques have been developed. This article points out the way. Humidity and water absorption have proven almost equal—0.015% in 5 days to 0.035% in 233 days—and thereafter no further moisture absorption takes place. Tests were also made under 4 atmospheres and at —70°C. There is a slight increase in absorption. Dipping in paraffin at 75°C has reduced moisture absorption in a 1-year test from 2.02% to 0.22%. In all moisture tests it is important to condition the sample.

Steam permeability was tested by putting 100 g silica gel on the outside of foam plate. In a 384-hr test 12.7 mm Hg pressure, about 7 g/182

cm² surface was absorbed. There is no effect of aging. An 8-year exposure to water immersion and a 3-year exposure to room temperatures indicate no increase in moisture absorption. Weathering in severe climates showed no change. Tests were made in tropical climates. Rain and insects do not affect the foam. During desert sun exposure there was a weight loss, and after six months the surface showed erosion. Termites seem to have bored holes when the foam was buried for six months.

Data and tests are also given for other properties and applications. This is a valuable article in the understanding of foams and test methods.

★

ARGENTINA
PLASTICOS
July, 1958

Abstracter: John B. Ballard

This entire issue is the first edition of the Guide of the Argentine Plastics Industry. It lists about 180 Argentine companies which mold, extrude, fabricate or produce plastics materials, and gives a variety of other information and statistics about the plastics industry in Argentina.

★

UNITED STATES
ELECTRICAL
MANUFACTURING
September, 1958

Abstracter: W. A. Kelley

Processing System for Optimum Design Use of Casting Resins—W. A. Gammel, Sr.

The difference between failure and success in a circuit resin embedment or components encapsulation may lie in the selection and proper use of the optimum resin handling system. Various commercial machines are described and associated data on molds and working environments are provided. Costs of batch, semi-automatic and automated processes are compared.

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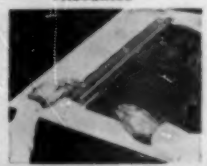

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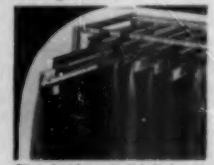

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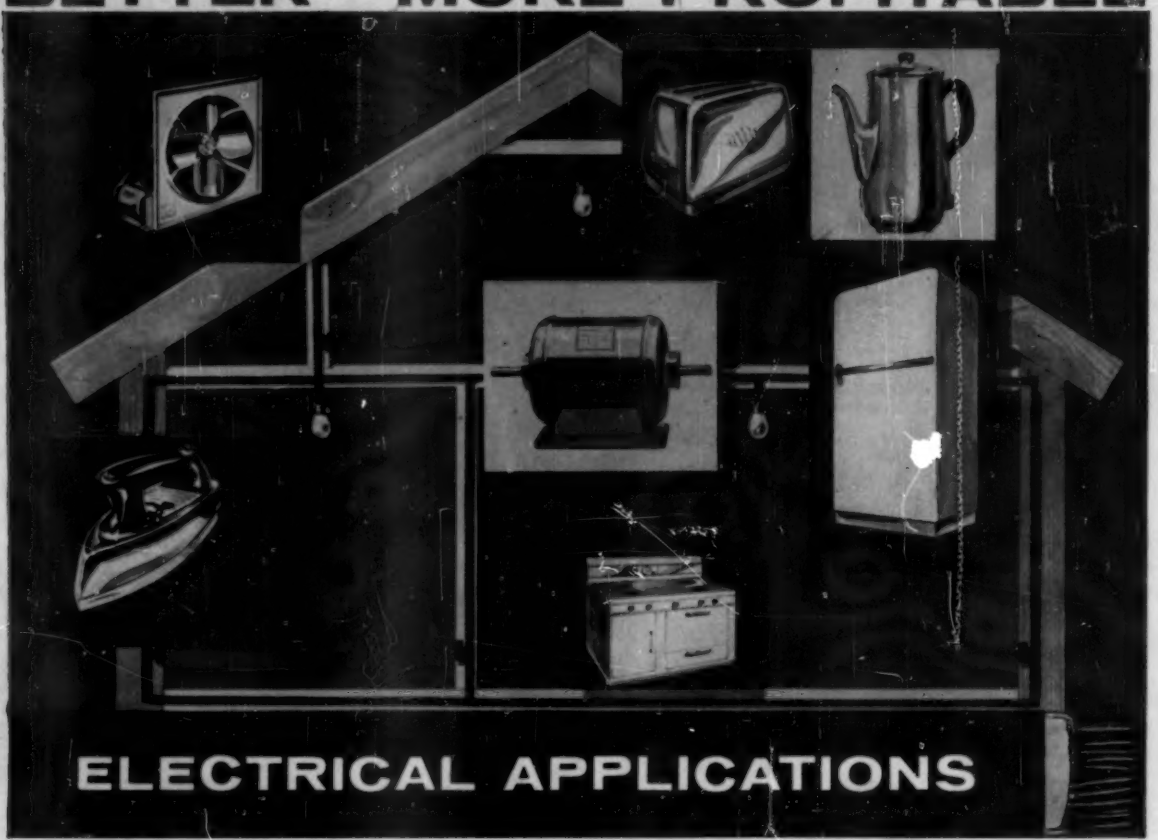

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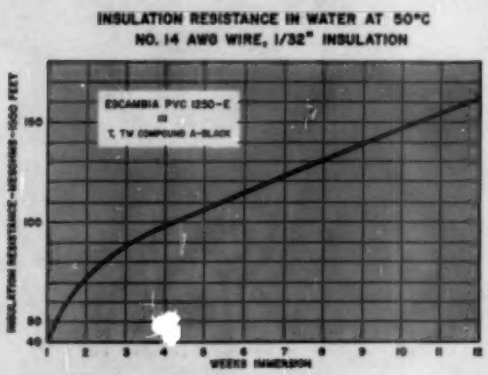

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